30-DAY OCEAN-BOTTOM SEISMOGRAPH, ALEUTIAN-KURILE OPERATIONS

by

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Program Manager

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Contract AF 19(628)-4075
Project No. 8652 Task No. 865205

Period Covered
1 October 1964 — 31 August 1965

FINAL REPORT

October 31, 1965

Prepared for

Air Force Cambridge Research Laboratories
Office of Aerospace Research
United States Air Force
Bedford, Massachusetts

WORK SPONSORED BY ADVANCED RESEARCH PROJECT AGENCY

ARPA Order No. 292, Amendment 14
Project Code No. 4810, Task 2

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PRINCIPAL CONTRIBUTORS

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ABSTRACT

The 30-day ocean-bottom seismograph senses ground motion through 1 vertical and 2 horizontal velocity seismometers and pressure variations through a transducer capable of response to 1.0 cps.

Data are recorded continuously on magnetic tape and the unit has a depth capability of 25,000 ft.

During the summer and fall of 1964, several drops were made in the area south of the Aleutian chain and northeast of the Island of Hokkaido, Japan.

Power density spectra of ambient noise samples over a long time interval were selected from the two areas. Plots of these data vs time are presented and compared with simultaneous meteorological maps covering the respective areas.

These results show a direct relationship between ambient noise levels and local meteorological changes. In fact, low-pressure disturbances were observed to cause up to 20 db increase in ambient noise level in the 0-2.0 cps range.

Ambient noise levels that previously were observed and reported appear consistent with current findings.

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SECTION I

INTRODUCTION AND SUMMARY

A. INTRODUCTION

Upon completion of the 1963 program (Contract AF19(604)-8368), Texas Instruments Incorporated was awarded a contract from the Air Force Cambridge Research Laboratories to construct ten ocean-bottom seismographs to the following specifications:

Shape		Spherical, 40-in dia.	
Weight			
	In air	With ballast	1620 lb
		Without ballast	1240 lb
	In water	With ballast	100 lb
		Without ballast	250 lb buoyancy
Operating depth (maximum)		25,000 ft	
Sensors		3 velocity, 1 pressure	
Sensitivity		Seismometers - 384 v/m/sec at 0.6 critical damping; pressure transducer 5 μv/microbar	
Type of magnetic recording		Data channels - direct analog	
		Time channels - digital	
Recording speed		0.0075 ips - 33 days on 8-in. reel of tape	
Number of recording channels		14 IRIG - analog	
Dynamic range		72 db overall - 3 output levels each data channel 20-db separation	
Timing control		40-day digital clock using crystal oscillator	
System frequency range		0.5 to 10 cps	
Power requirements		System total < 3 w Recorder only < 1 w	
Calibration		Each channel pulsed daily	
Emplacing		Free-fall to ocean floor	

Recall	By sonar command, preset time or upon saltwater leakage into sphere
Locate	Pulsed radio transmitter activated upon unit breaking surface. Located by directional antenna

These instruments were constructed and ready for ocean testing 18 June 1964. During late June and July the units were tested in shallow and deep water for reliable operation of the recall and recovery systems.

The last week of August five units were dropped south of the Aleutian chain near Adak in 10,000 to 18,000 ft of water. During the 30-day recording period several large charges (2376 lb) of composition B explosives were detonated as part of a joint program with the USC&GS to improve epicenter and hypocenter determinations (Figure 1).* After 30 days the instruments were recalled; however, two were not recovered.

For the final phase of the field program, the ship steamed to a point northeast of Hokkaido, Japan, where four units were dropped in water depths to 24,000 ft. Two of these units were recovered.

B. OPERATION

For launch and recovery, the seismographs are handled from an oceangoing vessel equipped with a boom or crane.

Prior to launch the instruments are completely checked to assure their proper operation, WWV is recorded on the magnetic tape and the sphere is sealed. Then the units are lowered into the water and released to free-fall to the ocean bottom. At a later date, usually after 30 days, the units are recalled by sonar transmission from a surface ship or by a preset time command. The recall activates a release mechanism, allowing the buoyant sphere to surface for recovery.

The instant the antenna emerges, a radio begins transmitting. This allows the recovery ship, using a Yagi antenna, to determine the direction toward the unit. Upon sighting the unit, the ship is brought alongside so that the unit is floating in the lee of the vessel. A safety hook is attached and the unit is brought aboard by boom or other lifting device. Then the sphere is opened and WWV recorded on the magnetic tape.

The tape is removed for inspection on a portable playback system before shipment to Dallas for transcription and analysis. Prior to the next launch, the unit undergoes a complete system check before installing new batteries and another magnetic tape.

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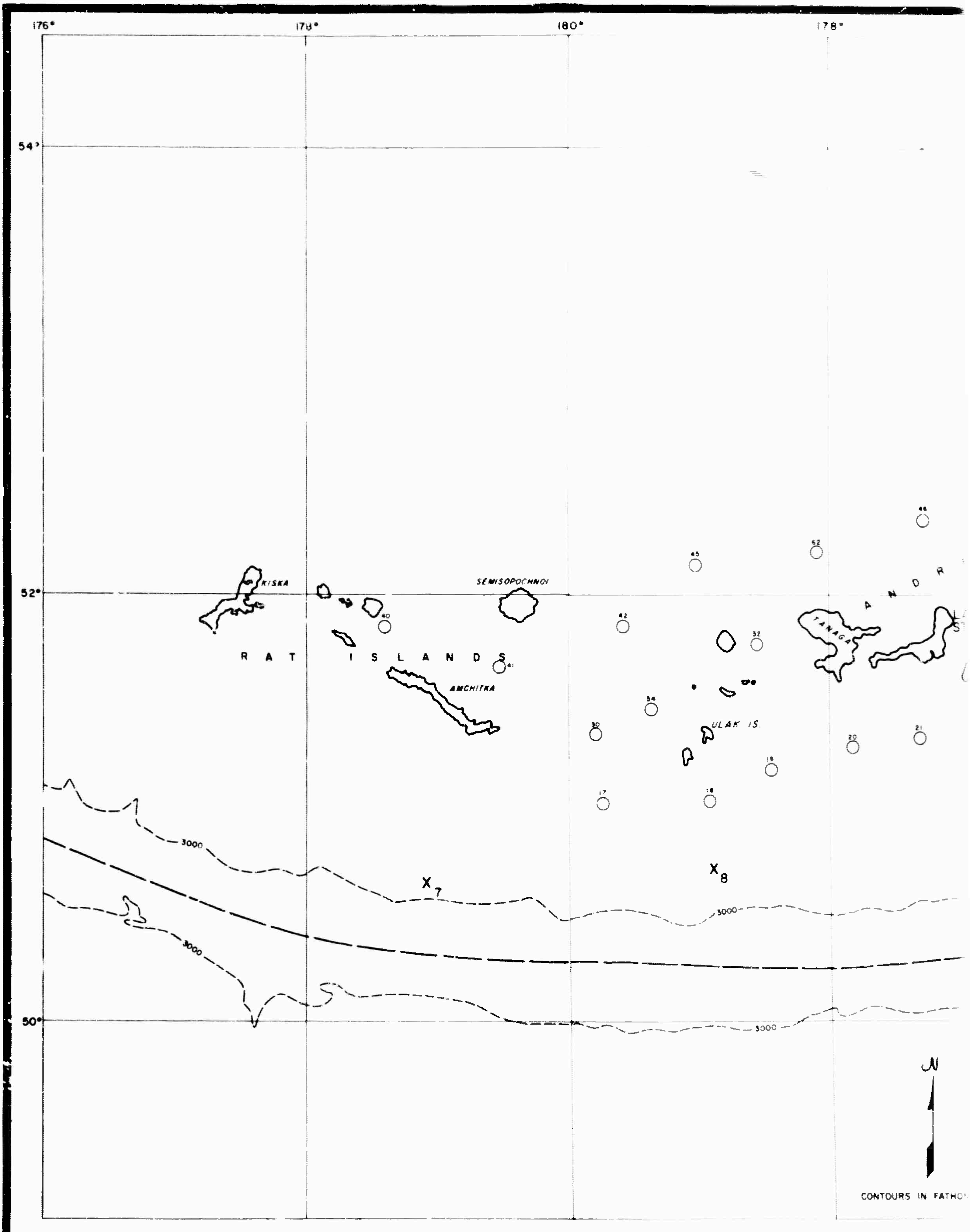
* Tocher, Don, 1964: VELA UNIFORM Aleutian Islands Experiment, VESIAC Special Bull., 10 June, p. 1-5.

Seismological Bull. for the VELA UNIFORM Aleutian Islands Experiment, 1964: USC&GS, Advanced Seismic Experiments Group (in press).


176°
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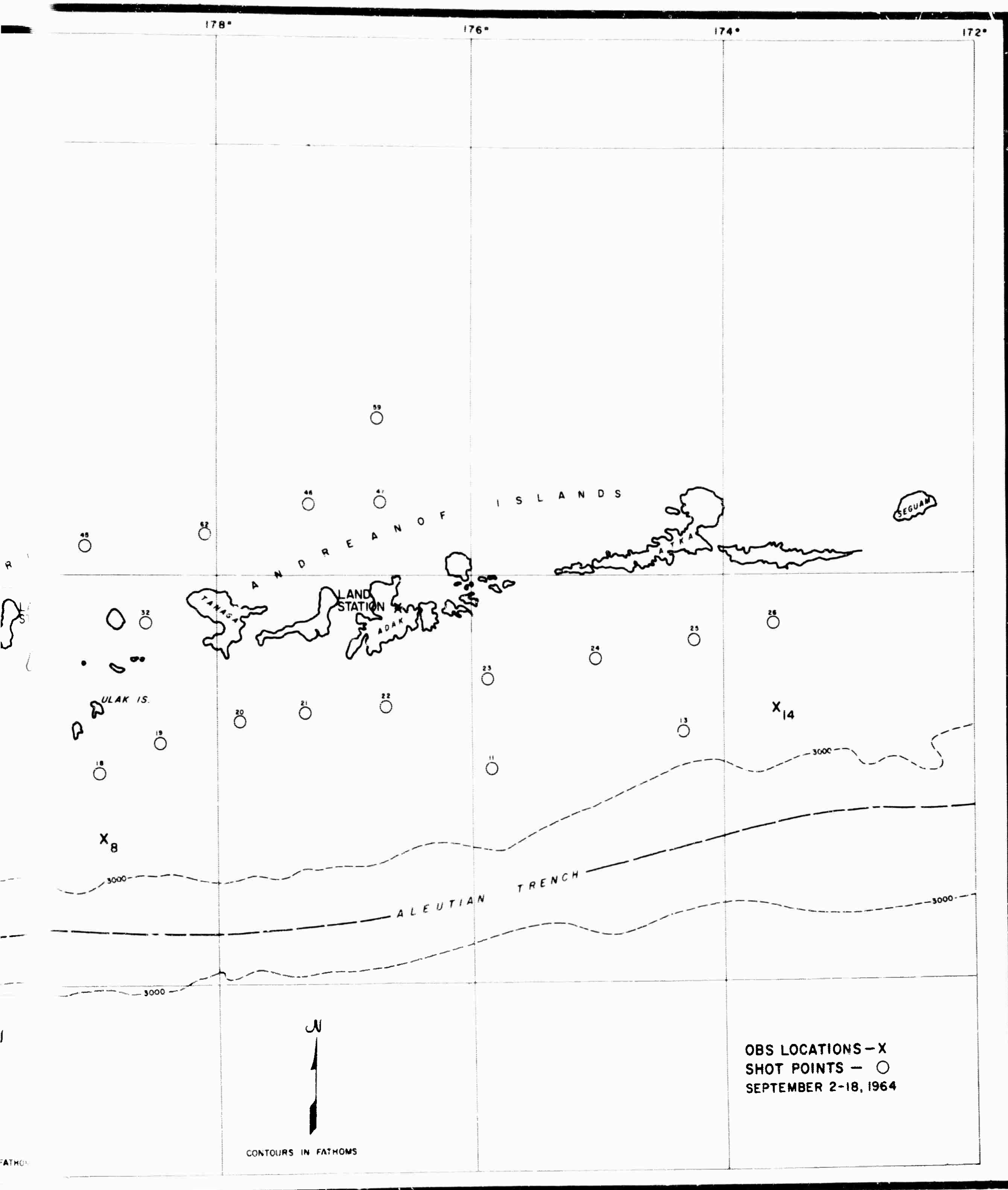

B

Figure 1. Map of Aleutians OBS and Shot Locations

C. DATA REDUCTION

For visual analysis, the magnetic tapes were reproduced on 16-mm film which displayed all 14 channels on a X-20 film viewer at a scale of 1 cm = 1 sec.

TI developed a fast playback system whereby a 30-day tape can be filmed in about 2 hr. This system includes a Fairchild 35-mm high-speed camera fitted with a 16-mm guide and a galvanometer bank. The film is processed separately. Existing transcription methods would require several months to process the approximately 22,500 ft of film involved.

All Aleutian and Kurile Islands film was scanned and event and noise samples were selected for digitizing and spectral analysis through TIAC*.

D. VISUAL ANALYSIS

1. Pressure Tranducer

Visual analysis showed the pressure transducer to be much lower in sensitivity than theoretically expected. No significant excursion was noted, except when an unusually strong local event occurred. In view of the excellent pressure data recovered from the previous ocean-bottom units,** this lack of sensitivity was a serious data loss. Investigation to determine the cause indicated a slight saltwater leakage in the transducer which generated a slight d-c leakage into the reactance amplifier. This resulted in decreasing the sensitivity of the transducer to low frequencies without seriously affecting sensitivity to the higher frequencies. The net result was that seismic data was adversely affected, whereas the recall signal was received at sufficient sensitivity to trigger the release.

2. P-Times from Aleutian Shots

The explosives program near Adak*** yielded P-arrival times for the USC&GS in conjunction with their efforts to obtain better travel-time data in the Aleutians. Table 1 lists the shot times, locations and , where possible, P-onset times. The P-times for position 8 are not presented because of clock drift.

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* Texas Instruments Automatic Computer

** Texas Instruments Incorporated, 1964, Ocean-bottom seismometer data analysis program: AFCRL Contract No. AF 19(604)-8368, Final Rpt., Oct. 12, Fig. 6, p. 16.

*** Texas Instruments, Incorporated, 1965, 30-day ocean-bottom seismograph: Semiannual Tech. Rpt. No. 2, Contract AF 19(628)-4075, Feb. 5, p. 7.

Table 1

P-ARRIVALS FROM SHOTS

Shot No.	Date	Origin Time (GMT)	Latitude	Longitude	Pos. 7	Pos. 14
23	9/2/64	23:11:00.0	51 29 15N	175 52 27W	EP 23 11 56.4	EP 23 11 28.8
22	9/4/64	23:36:59.75	51 22 09N	176 42 03W	EP 23 37 50.1	
21	9/5/64	02:46:00.06	51 20 13N	177 19 01W	IP 02 46 45.8	EP 02 46 40.6
20	9/5/64	05:54:00.02	51 17 39N	177 49 55W	IP 05 54 42.2	EP 05 54 46.7
11	9/7/64	05:27:00.00	51 03 32N	175 51 36W	IP 05 27 55.9	EP 05 27 31.8
13	9/7/64	18:24:00.02	51 14 44N	174 19 05W	EP 18 25 11.0	IP 18 24 14
26	9/7/64	23:05:00.35	51 46 02N	173 35 47W		EP 23 05 10
25	9/8/64	02:30:59.75	51 41 07N	174 14 08W		EP 02 31 11.9
24	9/8/64	05:57:00.17	51 35 51N	175 00 55W		
19	9/8/64	23:41:00.05	51 11 08N	178 27 13W		
18	9/9/64	06:27:00.25	51 02 26N	178 55 38W		
32	9/10/64	05:22:00.14	51 46 36N	178 33 43W		
62	9/11/64	21:30:59.92	52 12 03N	178 05 35W		
45	9/12/64	01:55:59.89	52 08 03N	179 01 17W		
42	9/12/64	06:03:59.76	51 51 15N	179 35 06W		
40	9/12/64	20:30:59.92	51 51 52N	178 35 58E		
41	9/13/64	02:01:00.15	51 40 11N	179 28 16E		
30	9/13/64	06:05:59.97	51 21 54N	179 47 42W		
46	9/15/64	19:06:00.20	52 20 24N	177 16 23W		EP 19 06 49.2
47	9/17/64	22:06:00.13	52 21 28N	176 42 52W		EP 22 06 42.2
59	9/18/64	01:22:00.21	52 45 14N	176 43 34W		EP 01 22 42.6
54	9/18/64	19:04:00.02	51 28 24N	179 23 09W		
17	9/18/64	22:56:00.23	51 02 02N	179 44 51W		

3. Hokkaido-Kuriles

No charges were detonated during operations in this area. Positions 2 and 4 are spotted on the Kokkaido-Kurile weather charts (Figures 7 and 8).

E. OPERATING TIME

Table 2 shows the total bottom time for each unit, measured from the moment the unit contacts the ocean floor to the start-of-recall time. Before each unit is dropped, WWV is recorded on the magnetic tape* and the clock is reset to zero. After the unit is dropped overboard, the moment of bottom contact is readily discerned from inspection of the film. Start-of-recall time marks the beginning of the recovery operation in that a coded sonar signal (each unit has its own sonar release code) causes the release of the appropriate unit from its anchor. An ocean-bottom unit is capable of recording for 30 to 33 days, depending on magnetic tape footage on the supply reel. An end-of-tape sensor then shuts off the recorder drive motor, leaving enough tape to record WWV after recovery. The operated (days) column of the table shows that all units recorded throughout the expected time, except at position 7 where recording stopped unaccountably after 12.7 days.

Table 2

Table 1

ON-BOTTOM OPERATING TIME

Position	On-Bottom (Days)	Operated (Days)	Remarks
7	35.6	12.7	Tape recorder stopped at 12.7 days
8	34.9	32.0	Slow clock rate. One-day-elapsed clock time is equivalent to about 1.55-day real time. Accurate event times were not possible
14	38.9	32.9	Severe tape speed variations after about 2 days' recording; consequently most data are not suitable for digitizing. However, accurate event times usually are recoverable
2	38.0	32.9	
4	30.9	30.9	

*Texas Instruments Incorporated, 1964, 30-Day Ocean-Bottom Seismograph: Semiannual Tech. Rpt. No. 1, Contract AF 19(628)-4075, Mar. 6, p. 1.

In the remarks column are brief statements about clock and tape speed problems affecting the quality of data. The units at positions 2 and 4 had no clock or tape recorder speed variations. Generally, all data was adversely affected by crosscoupling and package resonance problems which will be discussed later.

F. SOFAR Shots*

Enroute from the Aleutians to Japan, TI participated in a cooperative effort between ONR and the University of Hawaii to calibrate SOFAR velocities in the Northwest Pacific. During the 8-day cruise, 1.8-lb TNT charges were detonated at both 60- and 800-ft depths at predetermined locations. Table 3 lists the exact times and locations of these shots. Shot times were determined by recording shot impulses and WWV on a visicorder. The questioned times result from noisy WWV reception.

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* Texas Instruments Incorporated, 1965, 30-Day Ocean-Bottom Seismograph: Semiannual Tech. Rpt. No. 2, Contract AF 19(628)-4075, Feb 5. p. 11.

Johnson, Rockne H., 1965, A Program for the Routine Location of T Phase Sources in the Pacific, Hawaii Institute of Geophysics, Honolulu, Technical Summary Report No. 8, ARPA Contract No. Nonr-3748(01), March.

Table 3

SOFAR CRUISE DEPTH CHARGE TIMES AND LOCATIONS

Shot No.	Date	Time (GMT)	Charge Depth (ft)	Location	
SUS #1	10-15-64	19:46:07.90	800	175°03'00" E	50°50'00" N
		19:51:02.45	60		
		20:01:10.33	800		
SUS #2		20:56:01.25	60	174°55'30" E	50°49'20" N
		20:59:03.35 ?	800		
		21:06:04.22	800		
SUS #3		21:47:02.52	60	174°47'30" E	50°48'50" N
		21:51:07 ?	800		
		22:01:05.72	800		
SUS #4		22:38:01.18 ?	60	174°39'30" E	50°48'20" N
		22:41:04	800		
SUS #5		23:30:20 ?	60	174°31'30" E	50°47'50" N
		23:32:01.17	60		
		23:36:08.42 ?	800		
SUS #6	10-16-64	05:25:01.17 ?	60	172°34' E	50°42'00" N
		05:38:05.11	800		
SUS #7		06:26:03.42	60	172°25' E	50°41'45" N
		06:28:06.5	800		
SUS #8		07:06:00.59	60	172°17' E	50°41'30" N
		07:08:05.27	800		
SUS #9		07:47:00.8	60	172°09' E	50°41'15" N
		07:51:05.92	800		
SUS #10		08:28:03.03	60	172°01' E	50°41'00" N
		08:31:04.72	800		
SUS #11		19:48:03.12	60	170°25' E	50°39' N
		19:52:04.53	800		
SUS #12		20:31:03.5	60	170°18' E	50°39' N
		20:36:10.62	800		
SUS #13		21:11:00.79	60	170°10' E	50°39' N
		21:13:07	800		
SUS #14		21:56:02.44	60	170°02' E	50°39' N
		21:58:11.56	800		

Table 3 (Contd)

Shot No.	Date	Time (GMT)	Charge Depth (ft)	Location	
SUS #15		22:27:05.17	60	169°54' E	50°39' N
		22:36:04.92	60		
		22:41:04.73	800		
SUS #16		23:17:02.88	60	169°46' E	50°39' N
		23:21:04.83	800		
SUS #17		23:51:04.54	60	169°38' E	50°39' N
		23:56:04.35 ?	800		
	10-17-64	00:01:05.04	800		
SUS #18		00:43:01.24	60	169°30' E	50°39' N
		01:07:04.18	800		
SUS #19		22:16:02.25 ?	60	162°43' E	48°51' N
		22:22:06.37	800		
SUS #20	10-19-64	21:02:00.94	60	152°25' E	46°29' N
		21:06:05.85	800		
SUS #21	10-20-64	01:35:17 ?	60	151°10' E	45°50' N
		01:59:02.21	60		
		02:03:06.09	800		
SUS #22		07:32:01.99	60	149°52' E	45°06' N
		07:41:07.36	800		
SUS #23		20:27:00.92	60	148°12' E	44°22' N
		20:31:03.51	800		
		20:36:01.02	60		
SUS #24	10-21-64	02:06 ?	60	147°11' E	43°41' N
		03:02:09.92	800	147°17' E	43°35' N
SUS #25		08:38:02.21	60	146°14' E	42°56' N
		08:41:05.29	800		
SUS #26	10-26-64	23:36:00.19	60	145°11' E	39°48' N

SECTION II

ANALYSIS

A. NOISE ANALYSIS-ALEUTIANS

Noise data were digitized for positions 7 and 8 and the Adak land station. Samples of 3-min duration were taken every 6 hr for the vertical and one horizontal component (Table 4).

Table 4

NOISE DATA SAMPLES

Unit	Position	No. of Samples	Time (local) Taken During Day	Period (local) Covered by Samples
2	7	49	6, 12, 18, 2400	0600 26 Aug. to 2400 7 Sept. 1964
4	8	49	6, 12, 18, 2400	0600 26 Aug. to 2400 7 Sept. 1964
1	Adak	17*	2, 8, 2000	1800 31 Aug. to 2400 5 Sept. 1964

* The land station did not begin to record until 31 August. Inaddition, land spectra at 1400 (2400 GMT) were omitted because of difficulties in the playback clock decoder which wouldn't read time in the particular area of concern.

This table summarizes the number of samples analyzed and the period covered. Power spectra were computed for each sample and, once each day, the coherence between the vertical and horizontal components was obtained. As will be explained later, only data less than about 4.0 cps were considered valid. Also, since the predominant microseismic energy was confined to less than 2.0 cps, discussion is confined to the 0- to 2.0-cps region.

Figure 2 (in plastic pocket) shows the variations in positions 7, 8 and land spectra (in the 0- to 2.0-cps band) over a 13-day period. Spectral peaks are joined with a dashed line, average power levels (over a 16-cps band) with a solid line and the 2.0-cps power density levels with a dotted line. Also plotted are the variations of surface-wind velocity with time, as obtained from the R/V Seascope-Log. Figure 3 (in plastic pocket) shows one surface weather analysis chart for each day of the period. These charts were obtained from the U.S. Naval Weather Station at Adak.

Figures 2 and 3 show that the ocean-bottom power levels are directly related to the area weather conditions. On August 26 and 27, the isobars were widely separated, wind velocities were low and the ocean-bottom average-power levels also were low, about -15 db re 1 (μ/sec^2/cps at 1.0 cps).

An August 28, a strong low-pressure disturbance appeared approximately 1750 mi to the southwest and although still far from the ocean-bottom positions, the average power for both positions 7 and 8 increased 5 db during the day. During August 29, as the low passed through the area both ocean-bottom average-power levels rose to a maximum of about 0 db and the wind increased sharply. By August 30, the low was to the northeast and spectral levels and wind velocity fell, although not decreasing to the previous low level of August 26 and 27. The plateau reached on August 31 and September 1 corresponds to a between-storm period, but with higher average winds than on August 26 and 27.

The same pattern occurred September 2 to 4 as a second strong low passed through the area. The land station also reflected the passage. However, on September 4, levels fell very little because a new low already had formed to the southwest which passed through the area on September 5. Another low came from the West-Southwest on September 6; however, it was weaker and passed west of the area. Thus, on September 7, average-power levels were dropping.

The correlation between ocean-bottom power levels and weather conditions is summarized in Figure 4 which has a compressed time scale. The three lows that passed through the area are represented by the regions of high-wind velocities. In each case, average-power levels increased, resulting in an 18 db difference between the lowest levels (August 26) and the highest levels (August 29, September 3 and 6). The land station showed similar correlation, but did not span the full 13-day interval.

Figure 2 shows that ocean-bottom noise levels began to increase 1-1/2 days before surface wind velocities signaled the arrival of the low-pressure disturbance. From 0600 August 28 to 0600 August 29, the onset of a low-pressure disturbance is reflected by a 10-db increase in average-power levels at positions 7 and 8 and a 5-10 knot rise in wind velocity (note the sharp wind rise at 0600 August 29). This indicated that short-period microseisms generated by the August 29th low-pressure disturbance were propagated over significant distances (about 1750 mi).

From Figure 2 it can be seen that the spectral peak variations followed the average-power variations for both positions 7 and 8, indicating

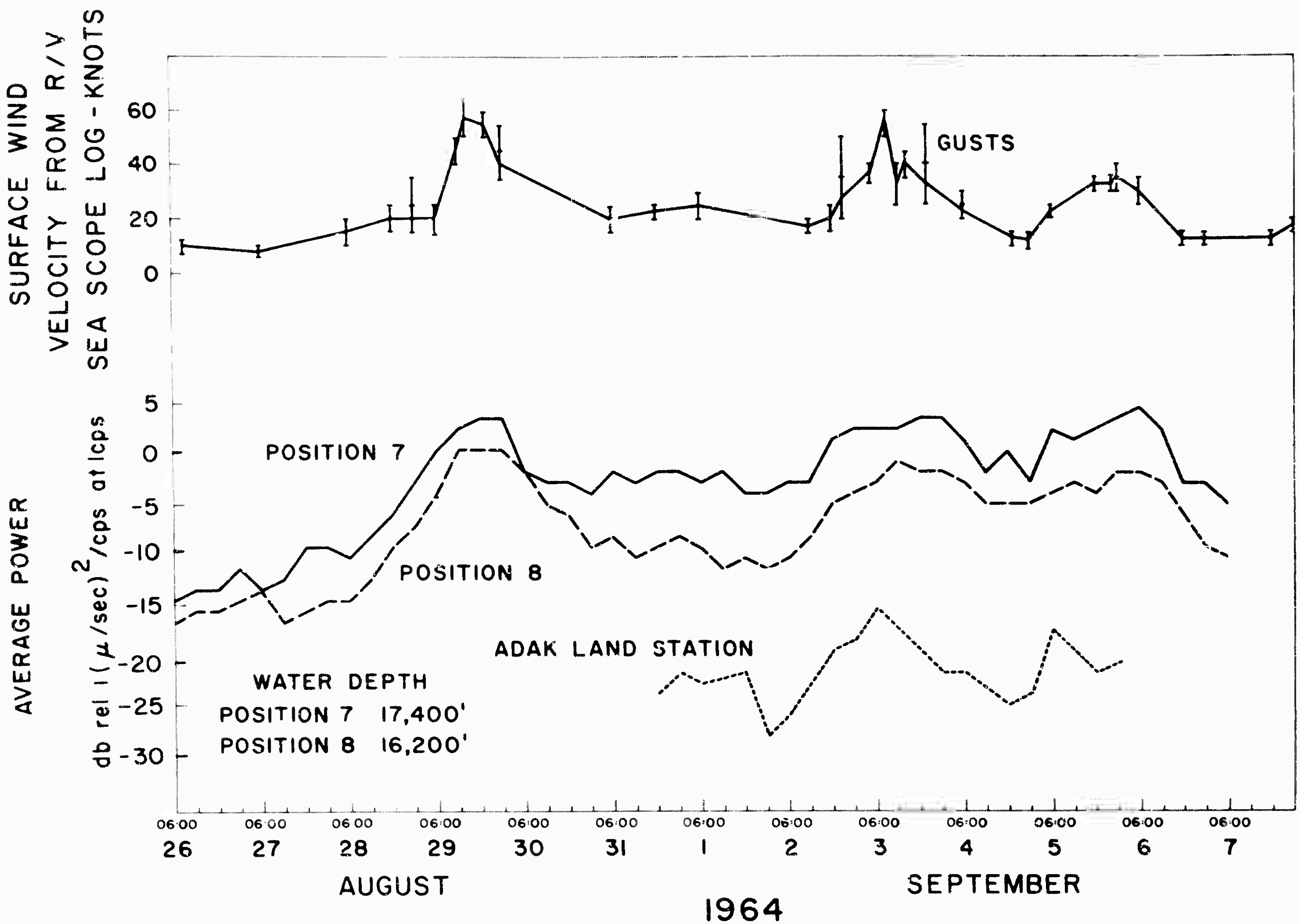


Figure 4. Variations in Average Power Levels With Time, Aleutian Data

that the low was generating microseisms with substantial power in the region of the spectral peaks. For position 8, the 2.0-cps power density-level variations also followed the average-power variations, suggesting that the low was a fairly broadband source. The agreement between 2.0 cps and average-power variations is less definite for position 7.

The vertical-horizontal coherences are low, as was found previously*. It was reasoned that when the low-pressure disturbances were large distances from the area (i.e., narrow-beam sources), but close enough to influence the ambient level, the vertical-horizontal coherences and/or phase angles could be affected enough to indicate how the energy was propagating. This was not the case. Apparently, when the disturbances were far enough away to be narrow-beam, energy arriving from them was not predominant. When close enough to become the predominant energy, the disturbances were no longer narrow-beam sources.

Figure 5 compares the average vertical spectrum for positions 7 and 8 (1964 data) with the Aleutian average for previous data on both the land and ocean-bottom units. Table 5 summarizes the number of spectra and the time period involved for each curve.

Table 5

NOISE SAMPLE AVERAGE VS TIME PERIOD

Instrument	Number of Noise Samples used in Average	Time Period Covered
Old OBS V	25	1 sample/hr for 5 hr for each of 5 days
Position 7 OBS V	37	4 samples/day for 13 consecutive days
Old Land V	40	1 sample/hr for 5 hr for each of 8 days
New Land V	11	3 samples/day for 6 consecutive days

*Texas Instruments Incorporated, 1964, Ocean-Bottom Seismometer Data Collection and Analysis: Contract AF 19(604)-8368, Final Rpt, Oct. 12, p. 37.

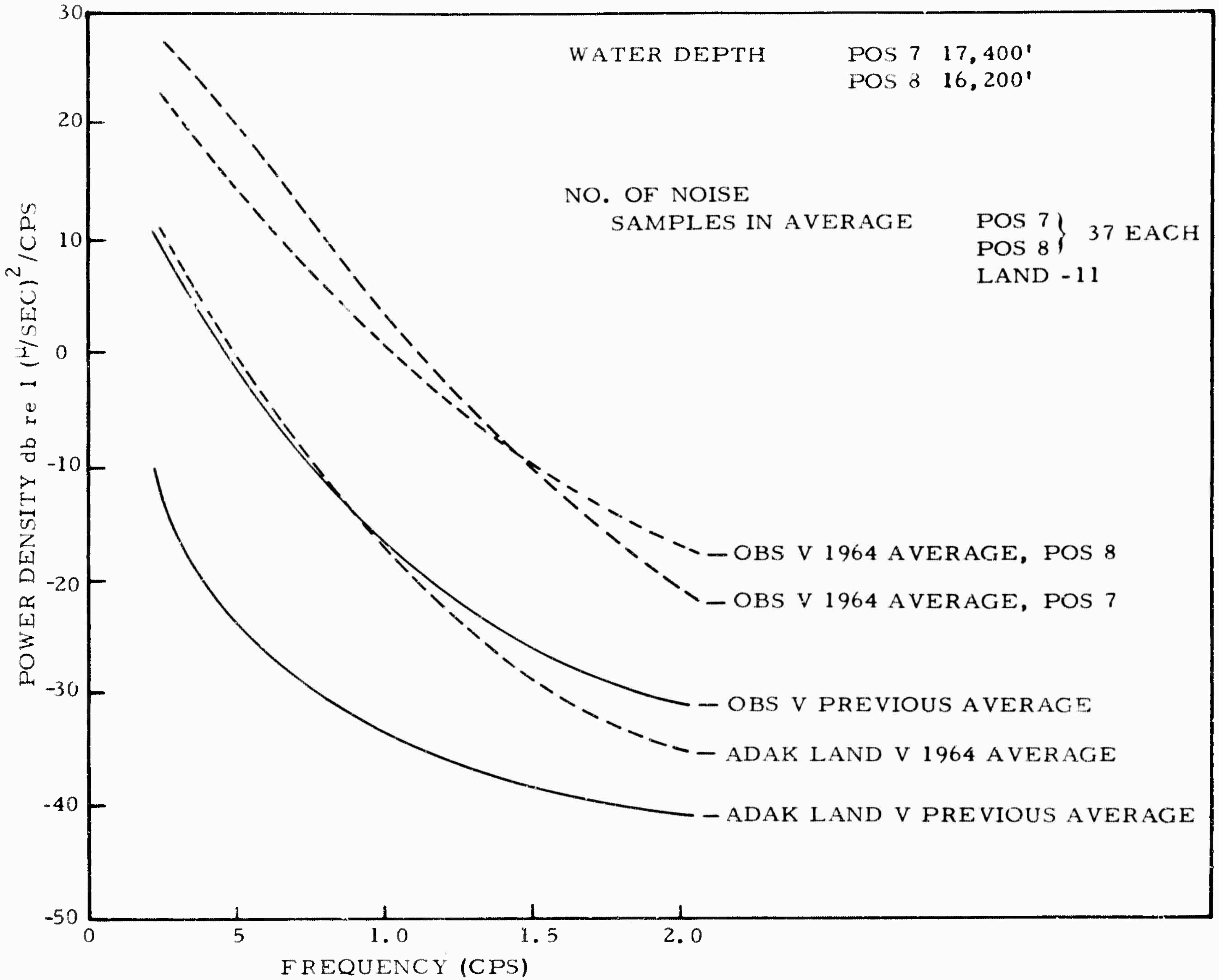


Figure 5. Average Power Density Spectra for Positions 7, 8 and Land Verticals for 1964 and Previous Data

It can be seen that the 1964 averages are substantially higher (about 18 db at 1.0 cps) for both the land and ocean-bottom data. A higher average would be expected since all previous data were collected during periods when good weather prevailed; however, over most of the 1964 period, average-power levels were well above minimum (or good weather) levels. Thus, based on the difference of 18 to 20 db between the maximum and minimum levels for the 1964 data, 1964 averages would be expected to be 12 to 15 db higher than previous averages, which accounts for the major part of observed difference.

In general, it can be concluded that the position 7 and 8 vertical curves are reasonably consistent with previous results, both in absolute and relative levels. As before, the OBS and land verticals differ by approximately 20 db.

B. NOISE ANALYSIS - KURILES

Noise data were digitized for positions 2 and 4. Samples of 3-min duration were taken at about 0800 local time each day for the vertical and both horizontals over a 30-day period from October 27 to November 25, 1964. Power spectra were computed for each sample and vertical-horizontal coherences were obtained every fifth day. Again, only data in the 0- 2.0-cps band were interpreted and displayed.

Figure 6 (in plastic pocket) shows the variations in the positions 2 and 4 spectra with time over the 30-day period. As before, spectral peaks are joined with a dashed line, average-power levels with a solid line and the 2.0-cps power-density level with a dotted line. Figures 7 and 8 (in plastic pocket) show one surface weather analysis chart for each day of the period. These Figures are for 0900 local time or about 1 hr after the noise samples were taken.

By comparing the spectra with the weather maps, the direct correlation between ocean-bottom power levels and regional meteorological conditions can be seen. There were four periods when average-power levels were relatively high: October 29, November 2, November 14-16 and November 22-24. In each case, a low-pressure disturbance was over or near the drop locations, as evident in the corresponding weather maps.

In addition, Figure 9, which summarizes the data on a compressed time scale, shows 7 periods for which the average-power curves had maxima. Each of these can be associated with a nearby low-pressure disturbance.

During periods of relatively low average-power levels, the only lows close to the station were on the west side of the Japanese mainland;

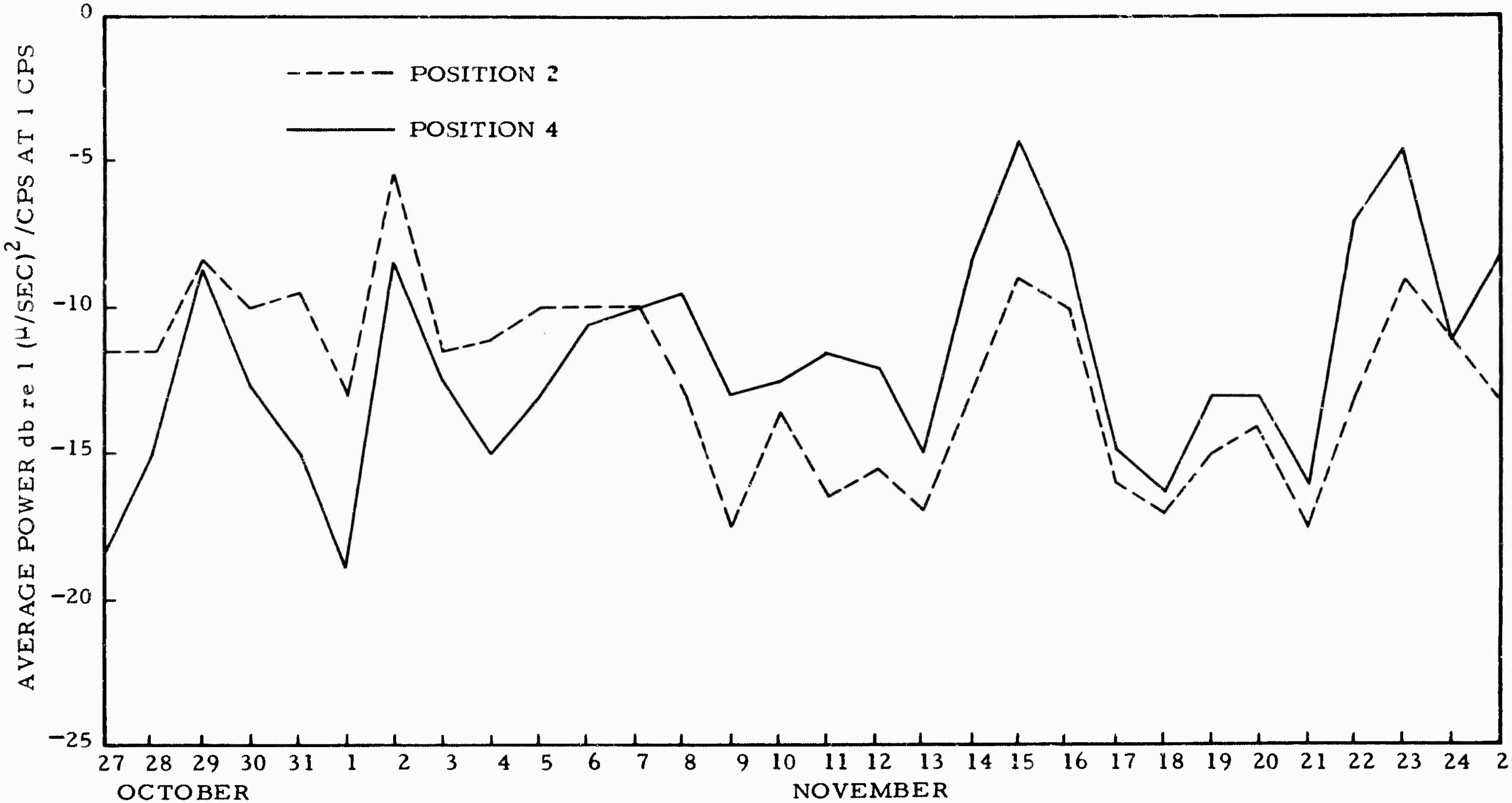


Figure 9. Variations in Average Power Levels With Time, Kuriles Data

these lows would not be expected to contribute much to the ocean-bottom spectral levels, because Japan would be an effective barrier for the generated energy. In general, when average-power levels were low, isobars were widely spread in the vicinity of units.

While there is a definite relationship between the power levels and weather conditions for the Kurile data, it is not as striking as for the Aleutians. This is reasonable because the low-pressure disturbances which passed through the Aleutian drop area were very well defined, quite intense and approached from the open sea. However, the Kurile lows often were weak and poorly defined. For the 4 obvious high-power levels previously mentioned well-defined strong lows did exist.

Figure 9 shows, as was the case in the Aleutians, the average-power levels for the 2 Kurile positions fluctuate in parallel over the entire 30-day period. For the October 27 to November 7 period, position 2 had higher levels than position 4, while for November 8 to 25 the opposite was true. In the Aleutians, position 7 always had higher levels than position 8. Having 2 units down simultaneously, showing the same level fluctuations with time, unquestionably rules out the possibility that the latter were due to instrumental drift.

Figure 6 shows that both the spectral-peak variations and the 2.0-cps power-density variations followed the average-power variations throughout the period. This again suggests that the storm centers, which are presumed to be the main cause of gross ambient variations, must generate energy in a fairly broadband, at least to 2.0 cps.

The vertical-horizontal coherences again were low in the 0- to 2.0-cps band. This agrees with the Aleutian and all previous analyses.

Figure 10 shows the average vertical spectra for positions 2 and 4, for position 8 Aleutian data and for previous Aleutian averages. The Kurile averages were obtained from 24 noise samples (with not more than one for each day) over a 30-day period. (The Aleutian averages were described earlier.) Position 2 and 4 averages agree very well and are between the two Aleutian curves. This result seems quite reasonable, since the old Aleutian data was low-biased due to collection of data in fair weather. The 1964 data were somewhat high-biased due to stormy weather over much of the period during which the units were on bottom. The Kurile averages were longer termed than the Aleutian averages and seem to have contained high, low and normal power levels. Since it was found previously that average levels were much the same at different locations*, it would be expected that the Kurile averages fall between the high and low Aleutian averages.

*Texas Instruments Incorporated, 1964, Ocean-Bottom Seismometer Data Collection and Analysis: Contract AF 19(604)-8368, Final Rpt., Oct. 12, p. 40.

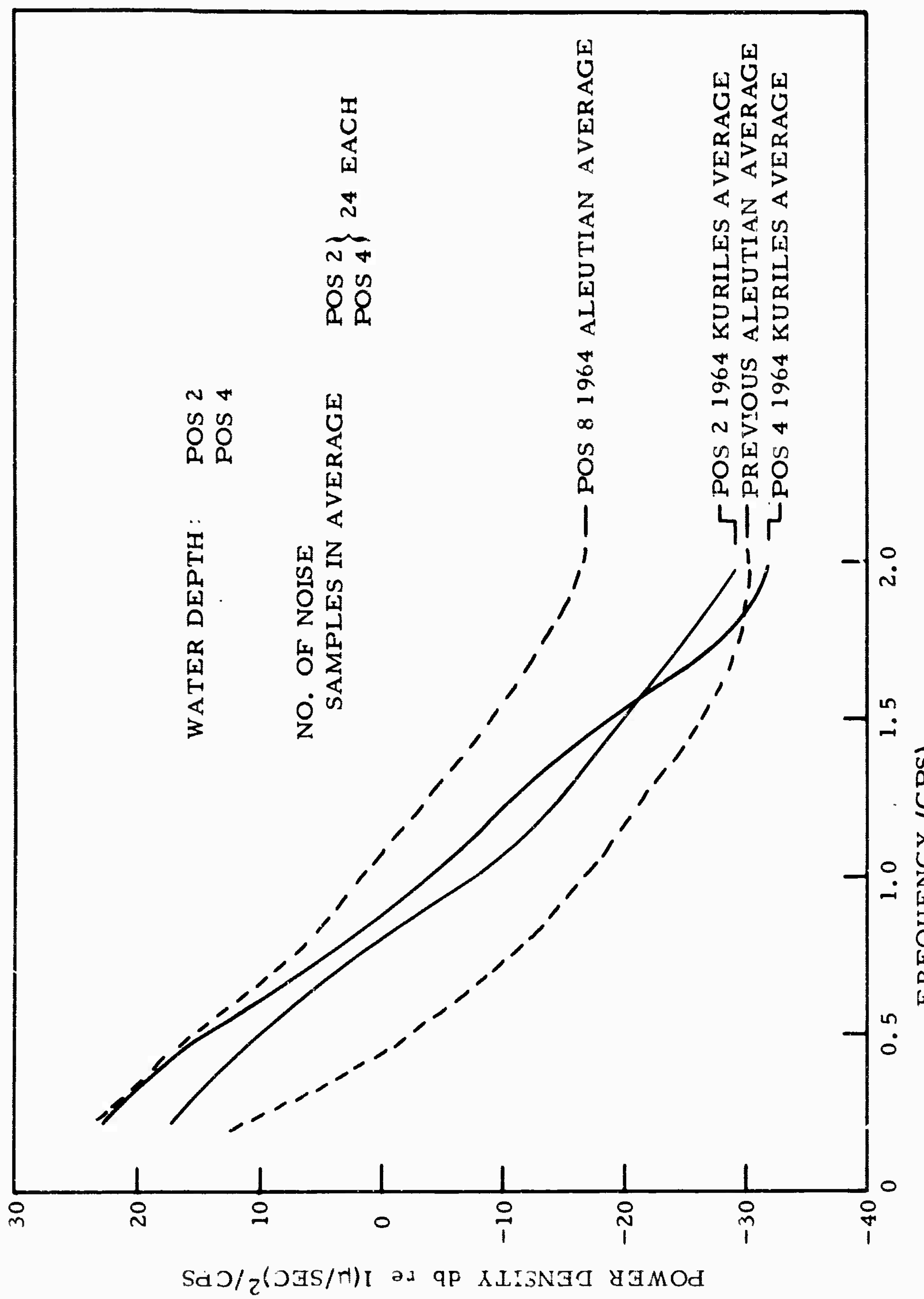


Figure 10. Average Power Density Spectra for OBS Positions 2 and 4, Kurile Verticals Compared With Aleutian Averages

C. SIGNAL ANALYSIS

After a close examination of the signal data, it was decided that computer analysis was not warranted. The vertical and horizontals exhibited dynamic crosscoupling between about 4.0 and 7.0 cps, which is the region of predominant signal energy for all the local or near-regional events. The crosscoupling was diagnosed from visual examination of the records, shake-table testing of the unit and analysis of noise coherences.

Figure 11 shows the 2000-lb calibration shot of September 8, 1964, as recorded on the OBS unit at the Adak land station. The OBS unit was placed on a concrete slab so that it would be rigidly coupled to the earth. Near the beginning of the arrival, the OBS V duplicated the Benioff reasonably well, although there was some indication in the record of crosscoupling, since the OBS V had more high-frequency content. Later in the record, however, the crosscoupling was severe and the OBS V showed no visual correlation with the Benioff.

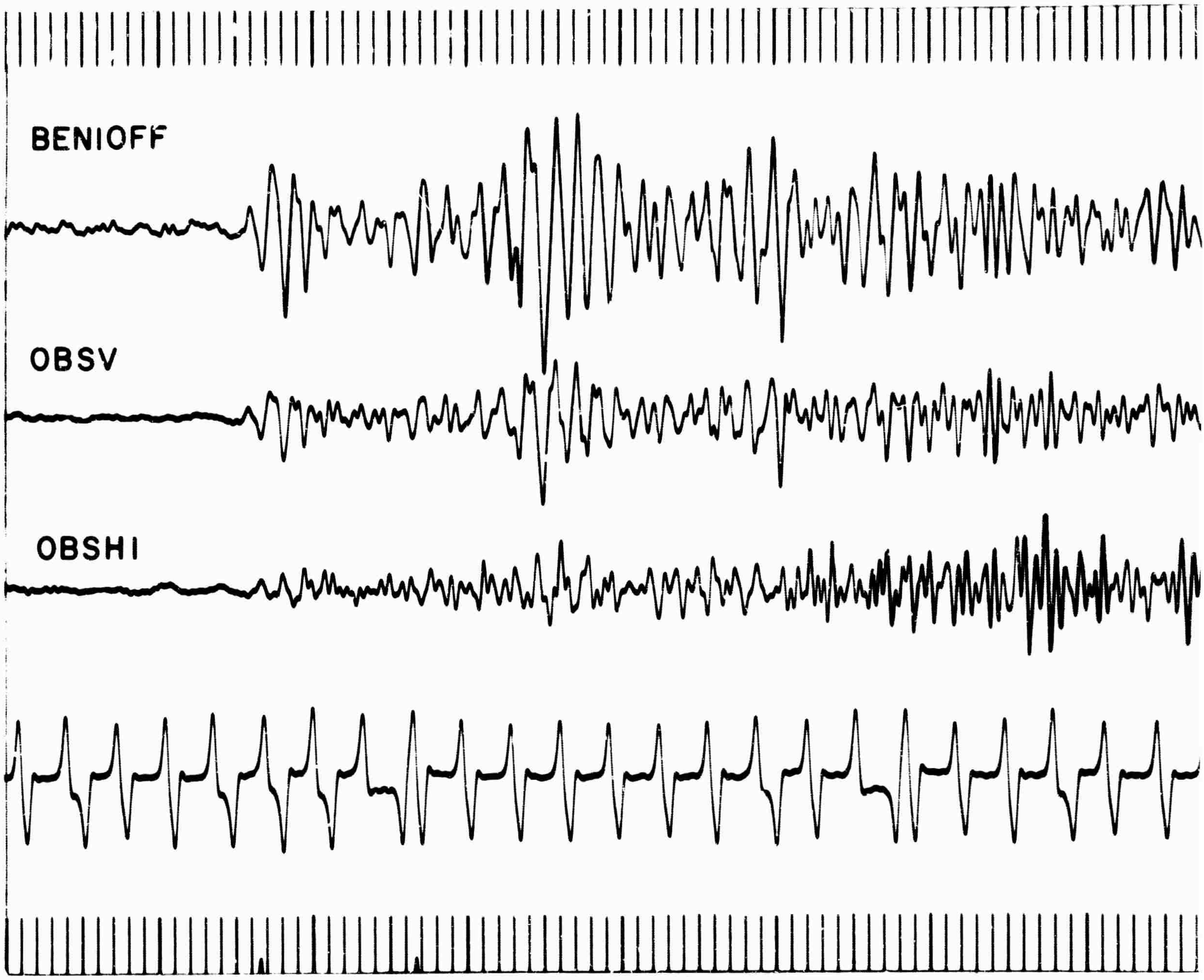
For the ocean-bottom units, the problem appeared much more serious. Figure 12 shows the same calibration shot as recorded at the position 8 Aleutian unit. High-frequency oscillation occurred immediately after the first arrival. The same type of phenomenon was observed for teleseisms. Evidently, the teleseisms contained enough high-frequency energy to set the system into oscillation. For noise, crosscoupling was observed, but was found not serious enough to affect the analysis in the low-frequency region (0.2 to 2.0 cps) where the noise power was peaked.

Mechanical crosscoupling has been eliminated in the new units by bottom-damping the gimballed assembly on which the seismometers are mounted with a high-viscosity damping compound. Figure 13 shows the coherence between an OBS vertical and an outside EV17 vertical, and an OBS horizontal and an outside EV17 horizontal (with the same orientation) for noise recorded in the laboratory. Very high coherence over the entire 1.0 - to 10.0-cps passband is obtained which means the OBS seismometers are acting independently. In addition, OBS and outside power spectra were virtually identical.

The reason for the more serious effect on the ocean bottom is not clear; it may have been due to poor package coupling to the ocean bottom. This problem will be examined closely in the California test phase.

D. SUMMARY AND CONCLUSIONS

Our analysis has shown that variations in the ocean-bottom ambient-noise level are directly related to local meteorological conditions. In periods of severe weather conditions (i. e., low-pressure disturbances), the ocean-bottom ambient rises as much as 18 to 20 db in the 0- to 2.0-cps



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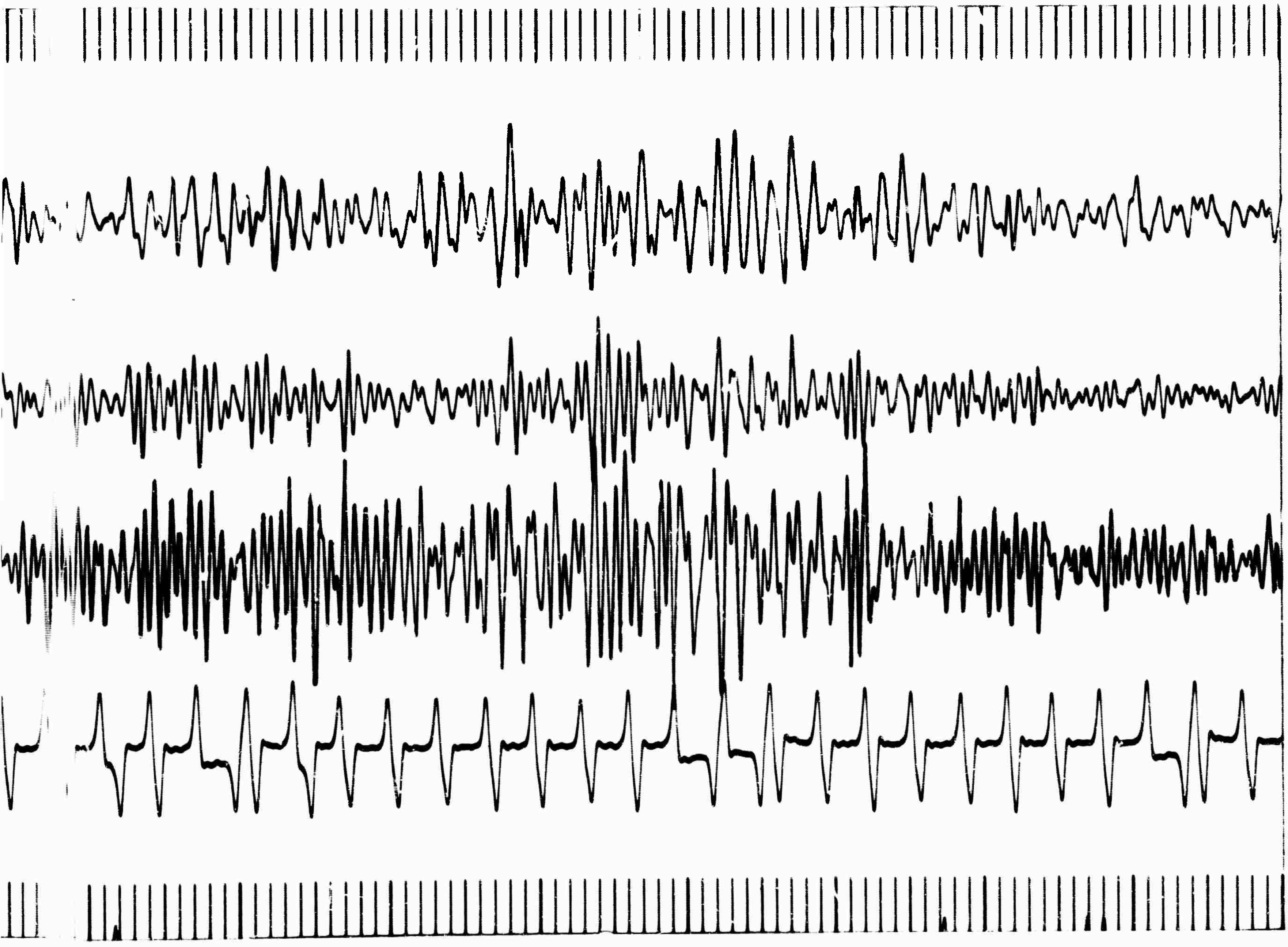
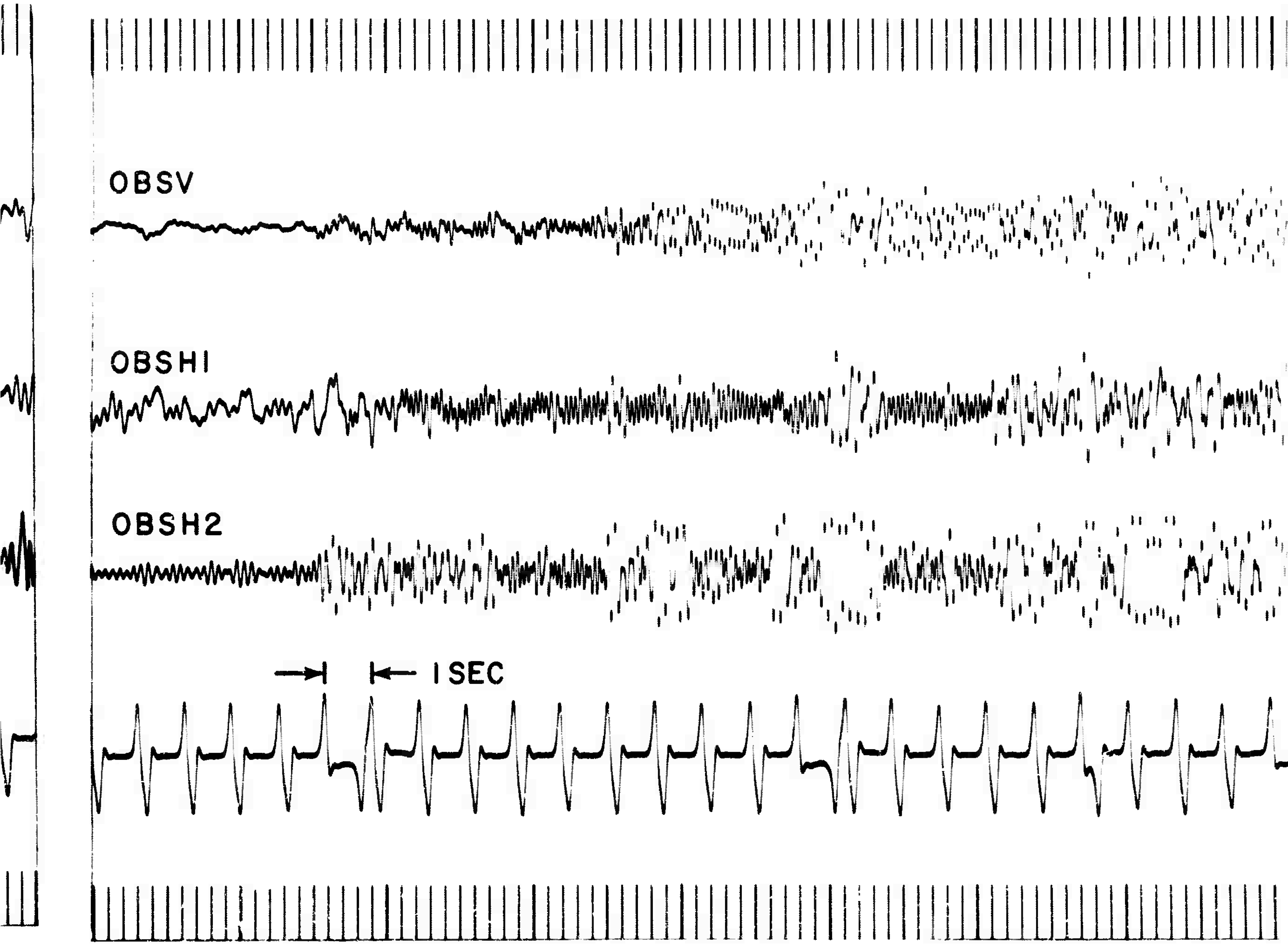


Figure 11. Calibration Shot of September 8, 1964 as Recorded at ADAK Land Station

B



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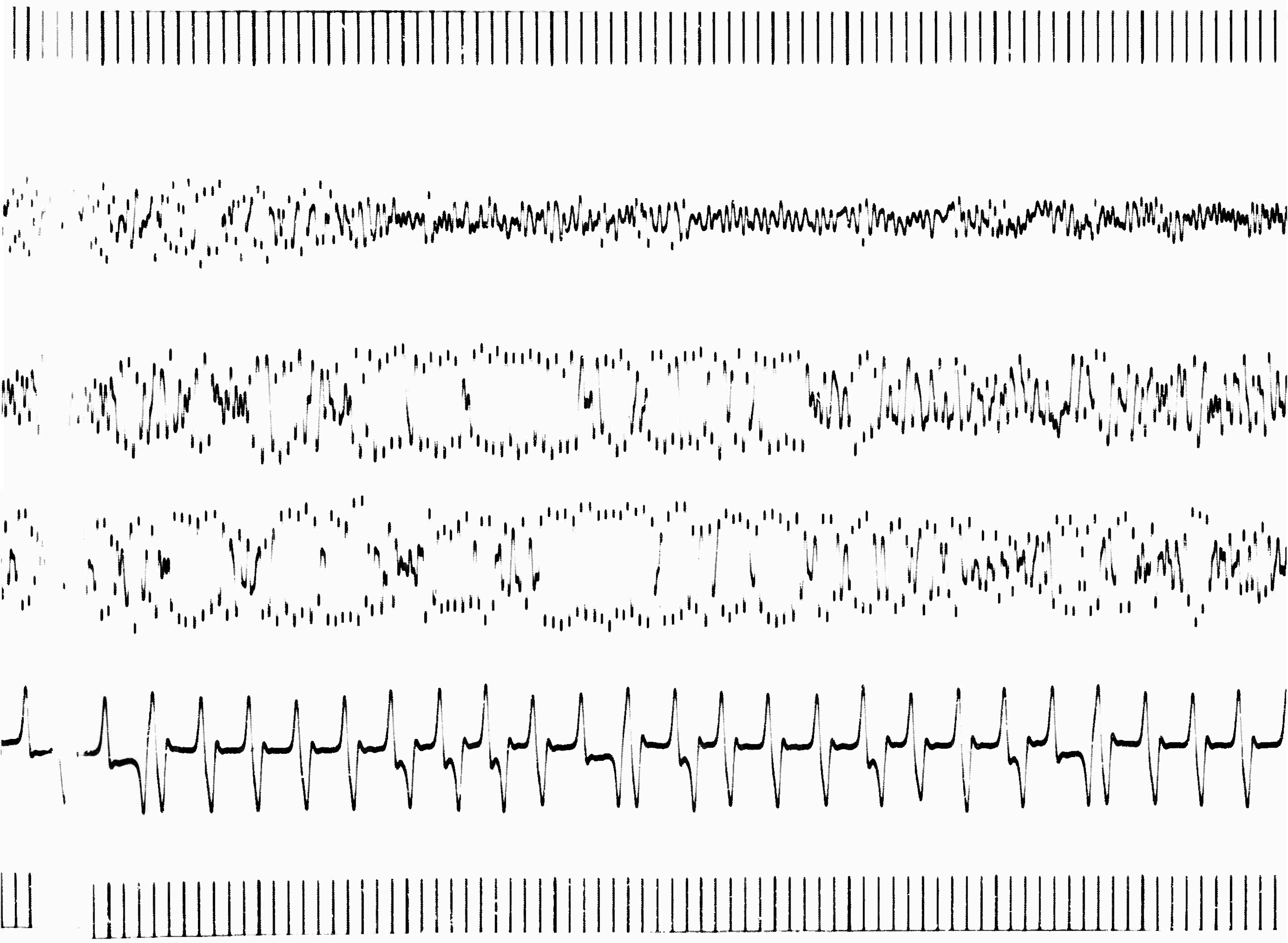

Figure 12. Calibration Shot of September 8, 1964 as Recorded at Position 8, Aleutian

B

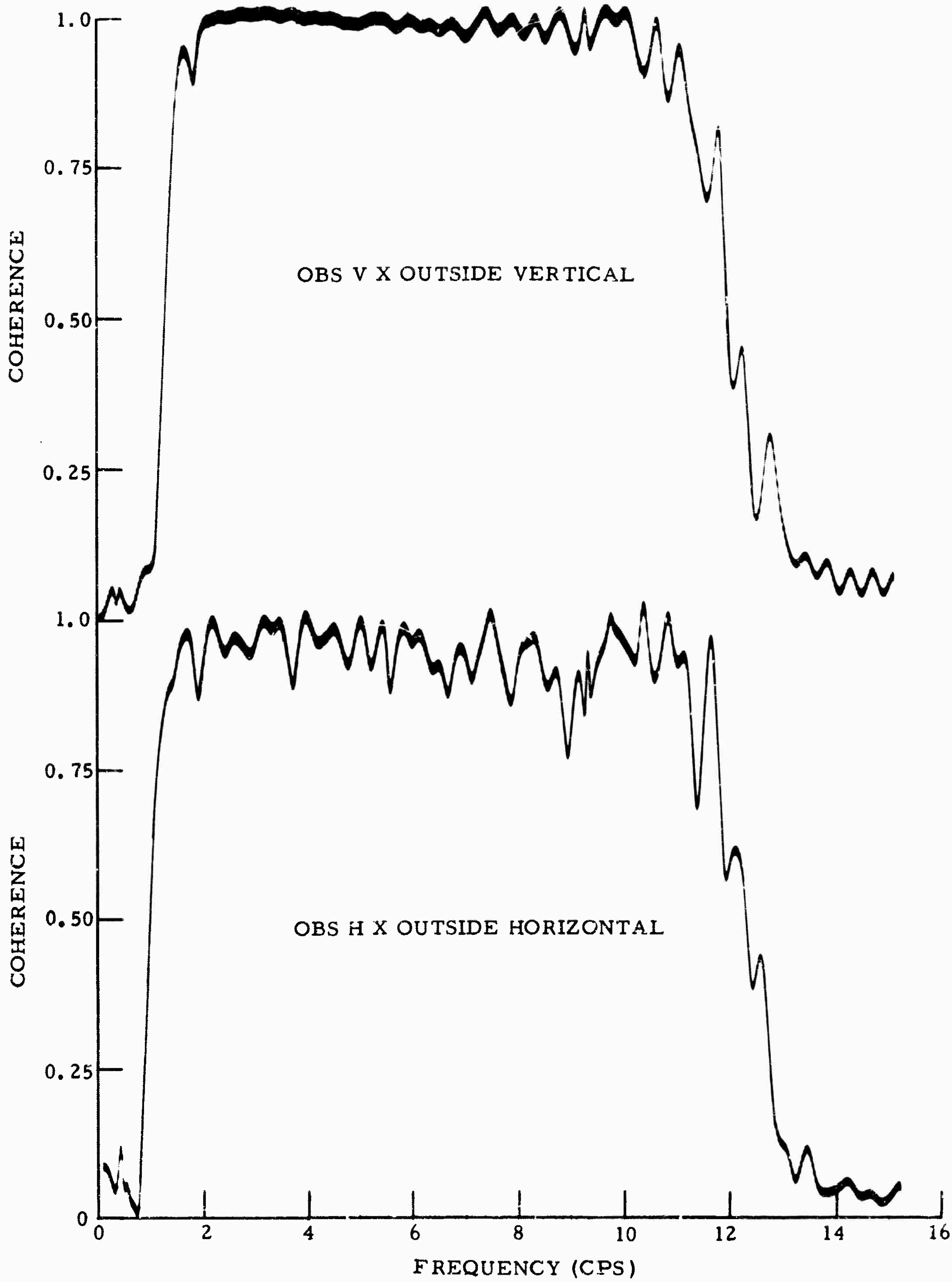

Figure 13. Coherence Between OBS V and Outside Vertical; OBS H and Outside Horizontal

range. Ewing and Prentiss (1963)* also studied the problem and found some, but not conclusive evidence for a relationship. The results of Bradner et al (1965)** indicated that low-pressure disturbances contributed to the ocean-bottom ambient. The long-recording instruments provided the capability for the first study of this nature where continuous ocean-bottom recordings in all weather were made available.

Our analysis also indicated that low-pressure disturbances generate microseisms in a band of at least 2.0 cps and that microseisms from the lows propagated as far as 1750 mi.

Results of the 1964 noise analysis are consistent with previous analysis. Noise levels on the ocean bottom are about 20 db higher than on land. Average Aleutian noise spectra were higher for 1964 than for previous data because most of the 1964 data analyzed were recorded during periods of active local weather conditions. Due to necessity, the previous data were recorded during fair-weather conditions.

No signals were computer-analyzed because of instrumentation problems (dynamic crosscoupling of the vertical and horizontal seismometers in the 4.0- to 7.0-cps range). This problem has been corrected in the new units.

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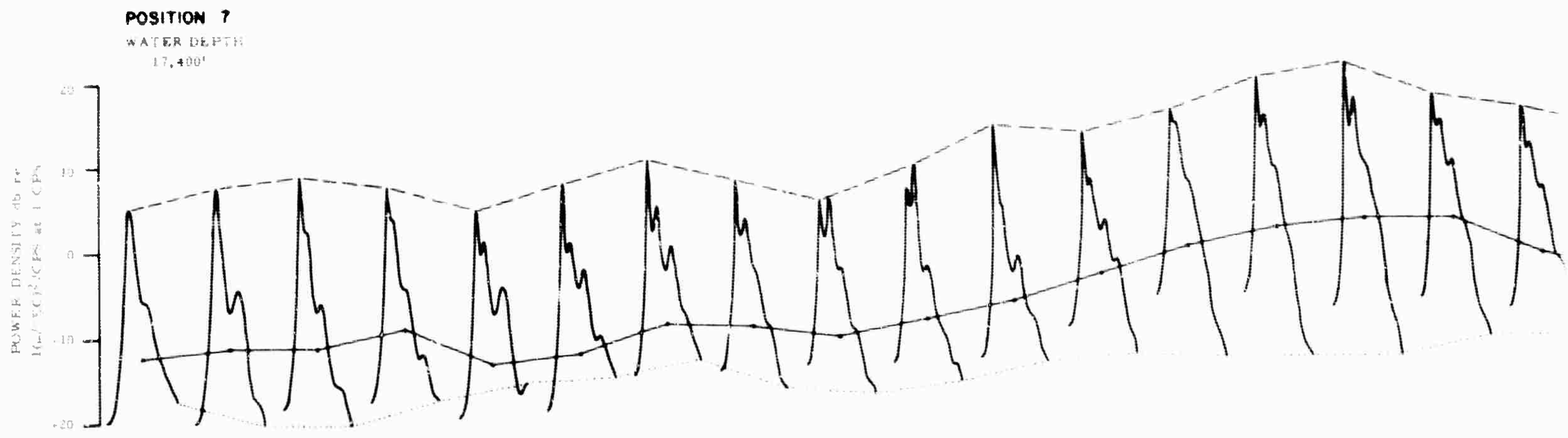
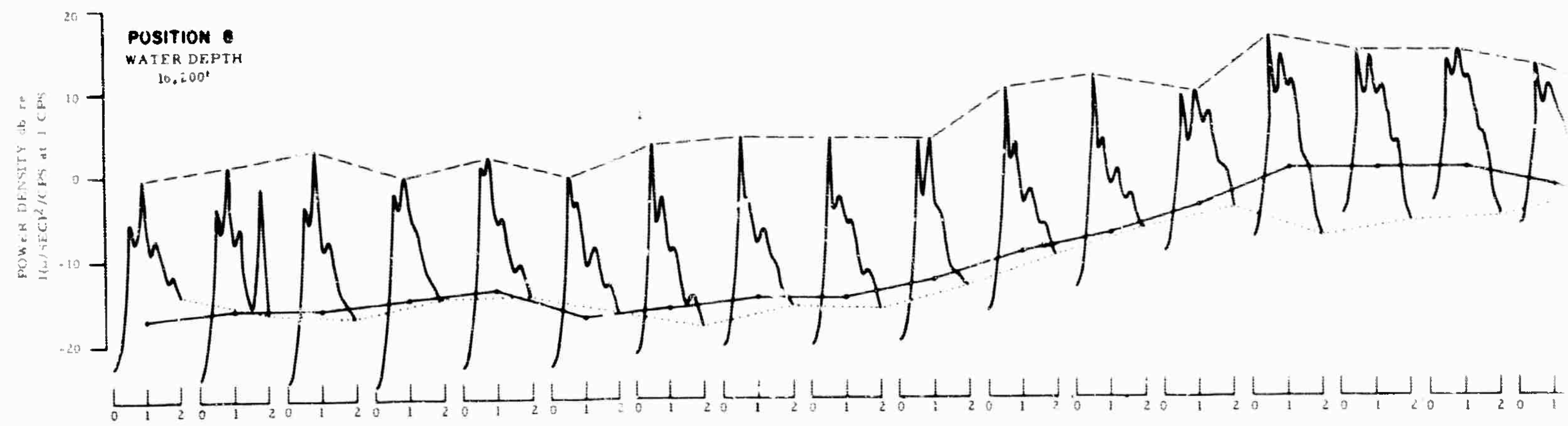
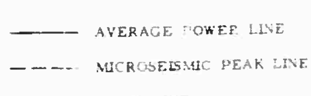
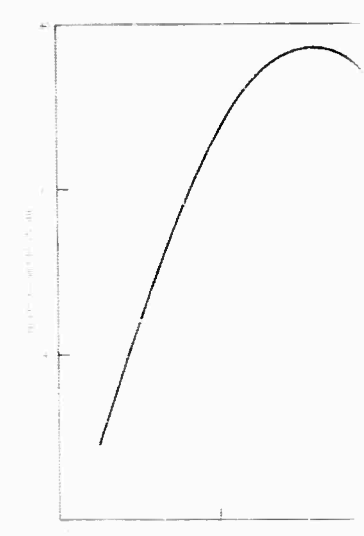
* Ewing, J. I. and D. D. Prentiss, 1963, The seismic motion of the deep ocean floor: Bull. of Seis. Soc. of Am., v. 53, n. 4, p. 765+.

**Bradner, H., J. G. Dodds and R. E. Foulks, 1965, Investigation of microseismic sources with ocean-bottom seismometers: Geophysics, v. 30, n. 4, Aug., p. 511-526.

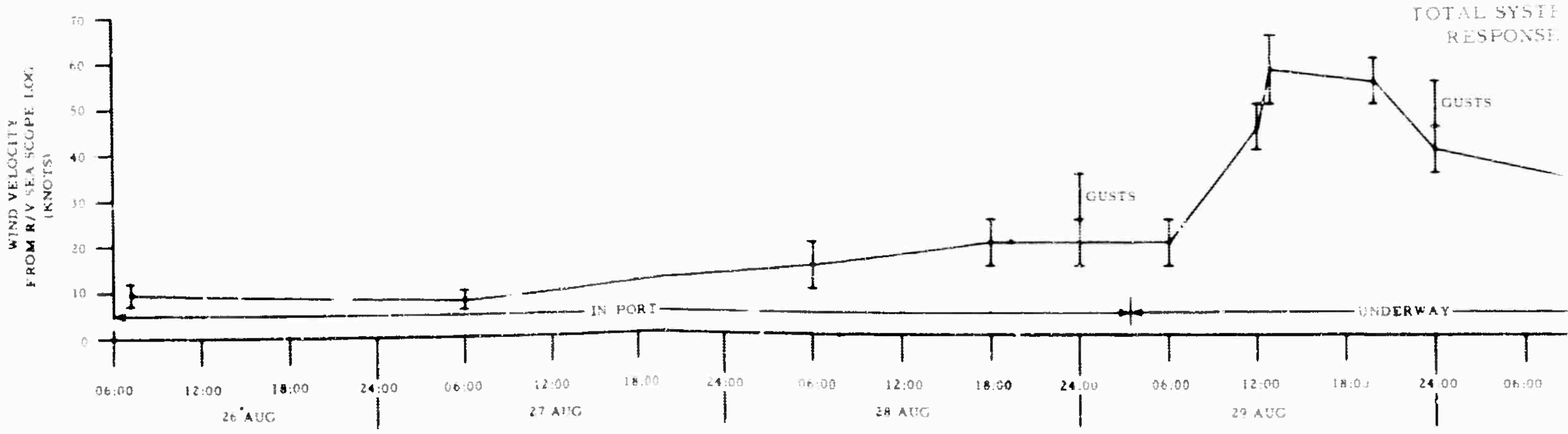








TOTAL SYSTE
RESPONSE



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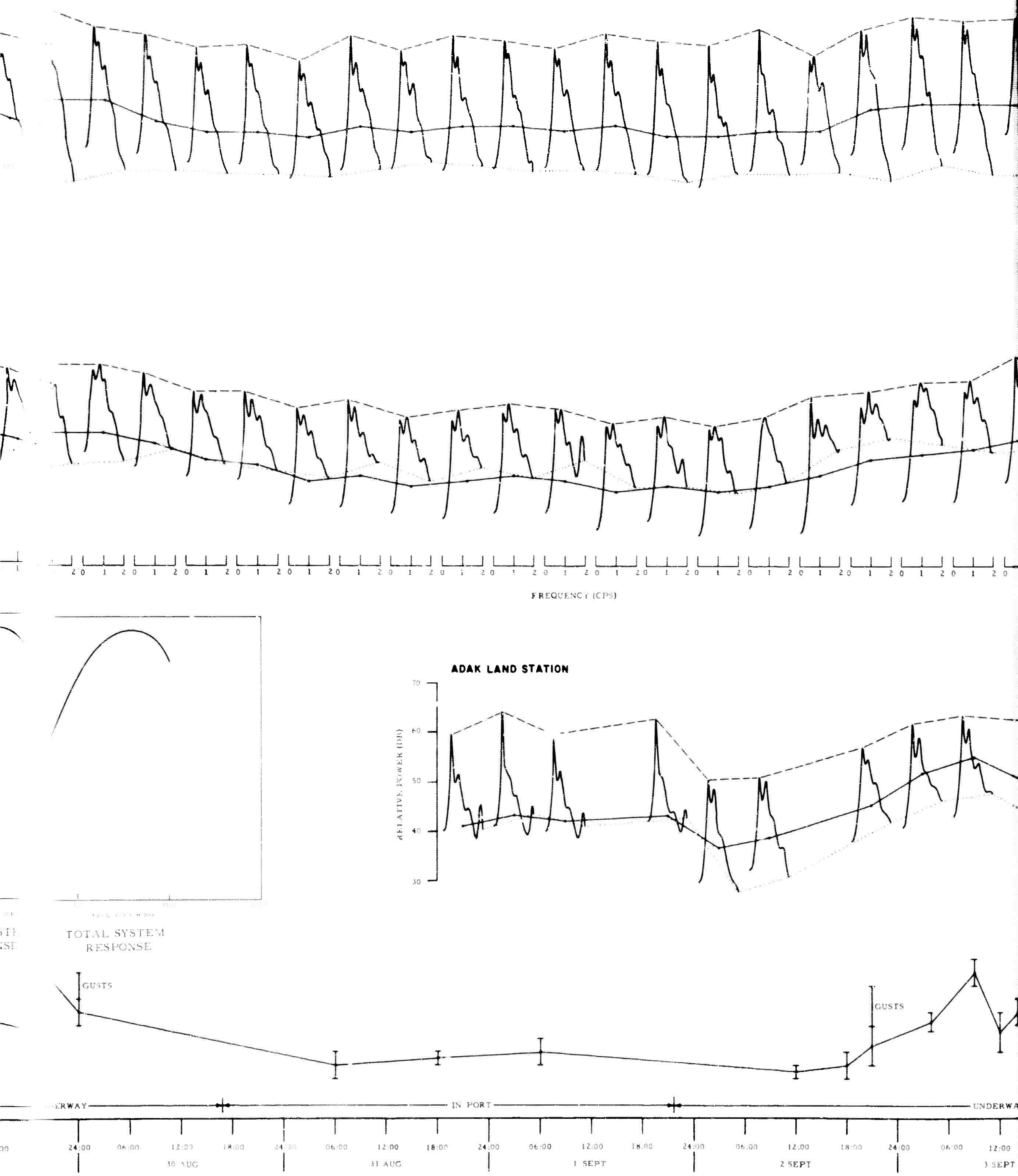


FREQUENCY (CPS)
TOTAL SYSTEM RESPONSE
ADAK LAND STATION
RELATIVE POWER (DB)
70
60
50
40
30
GUSTS
GUSTS
IN PORT
UNDERWAY
24:00
06:00
12:00
18:00
30 AUG
31 AUG
1 SEPT
2 SEPT
3 SEPT

B

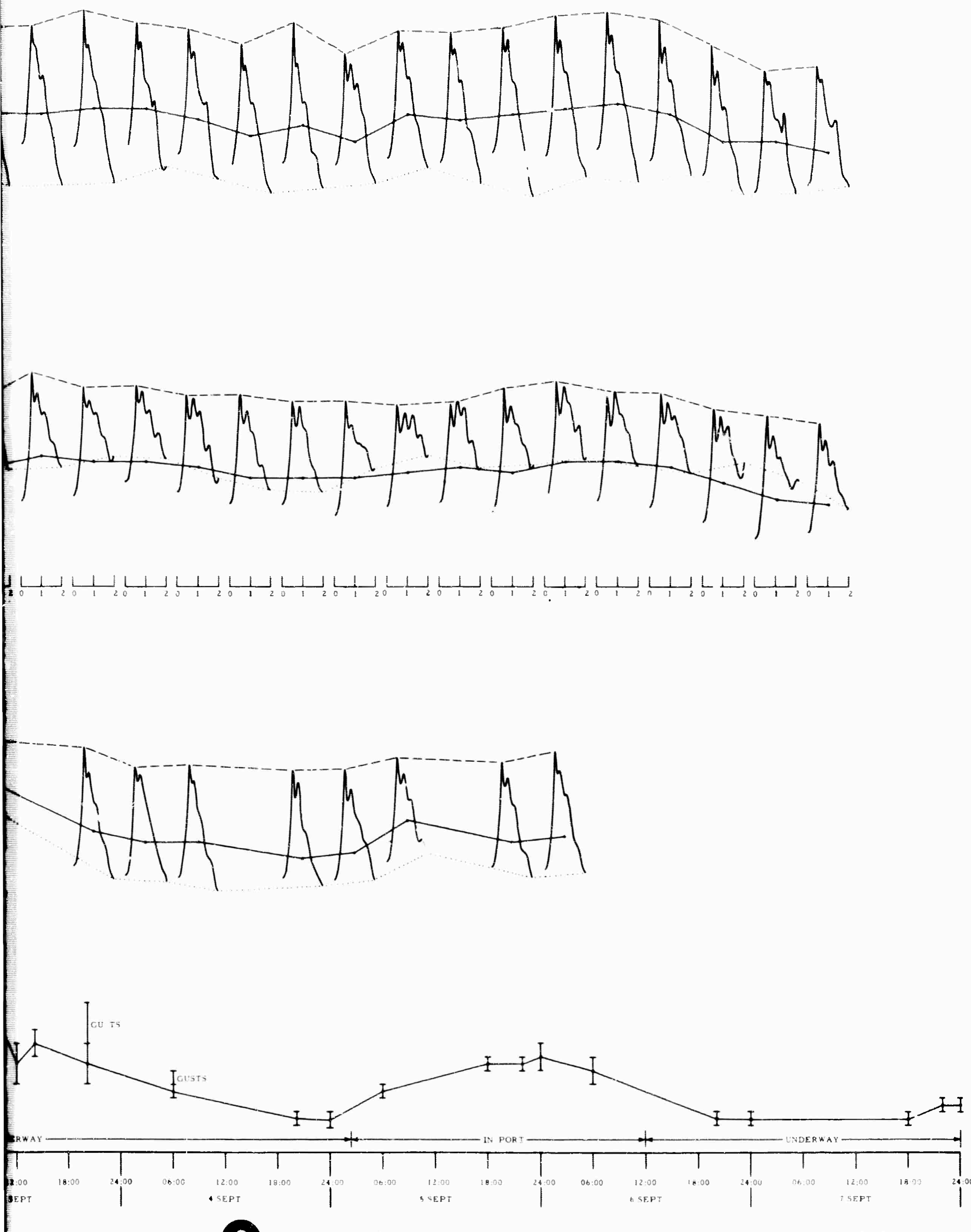
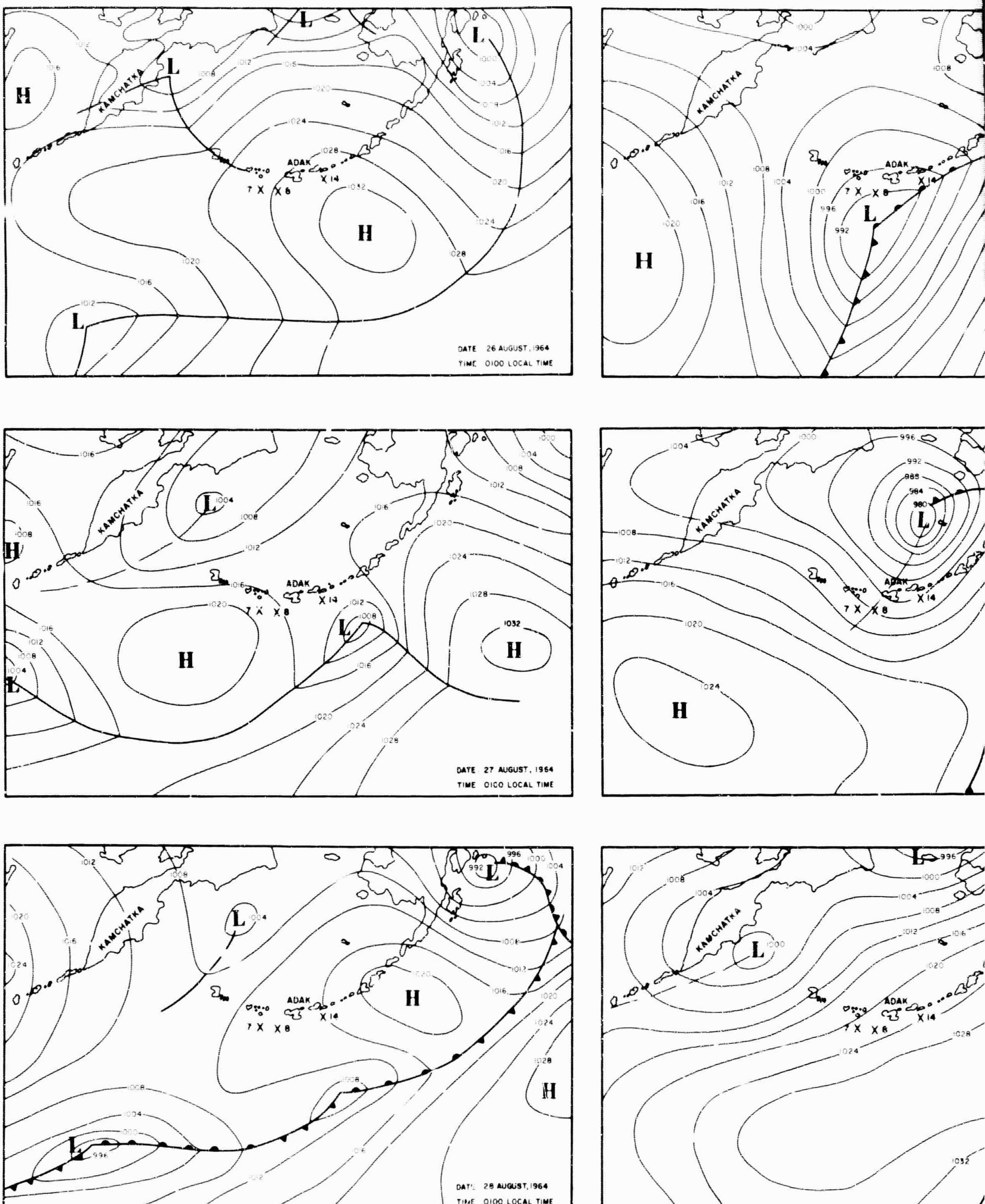


Figure 2. Spectral Variations with Time in the 0 to 2.0 CPS Band; and Wind Velocity Variations


KAMCHATKA
ADAK
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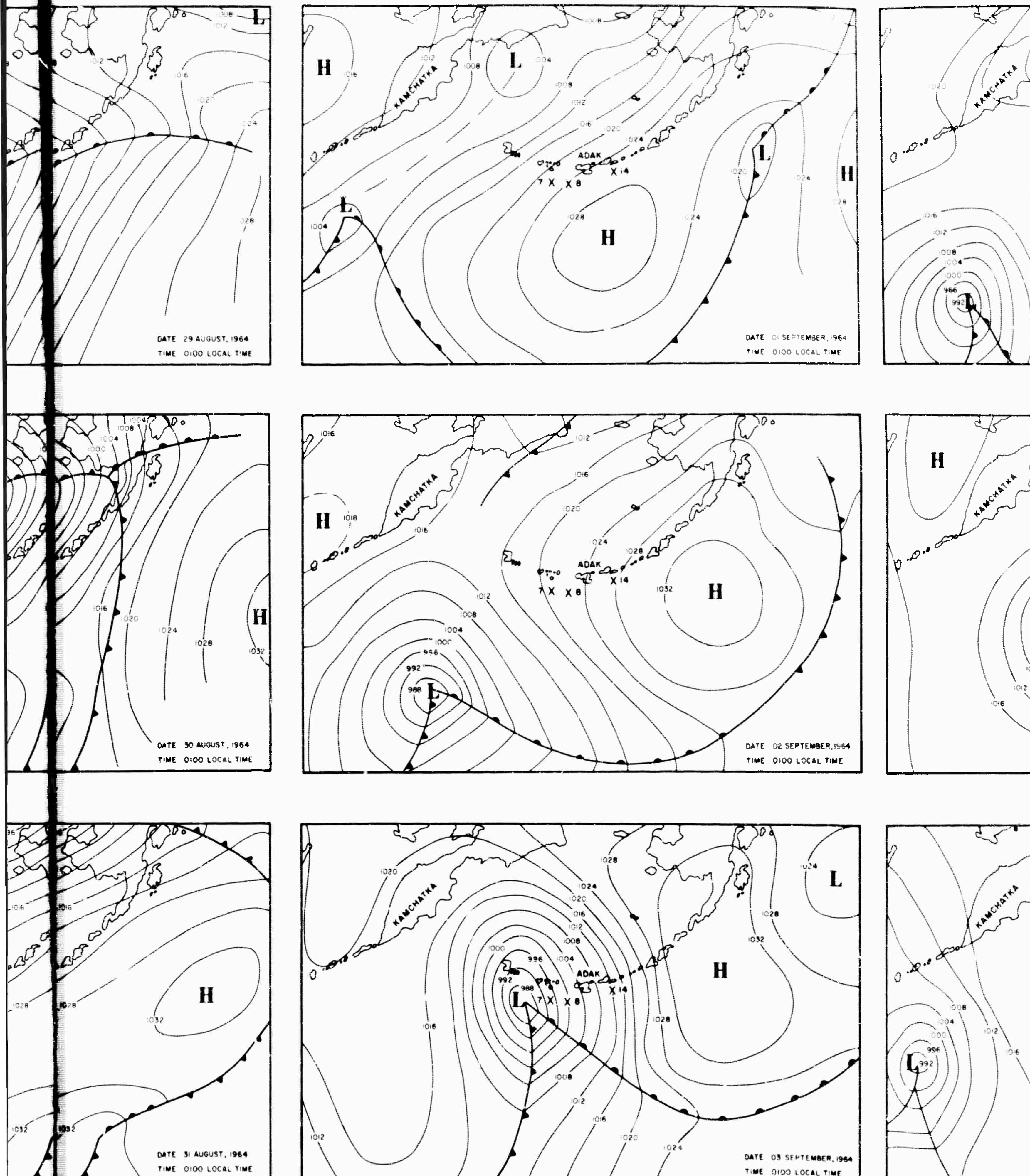
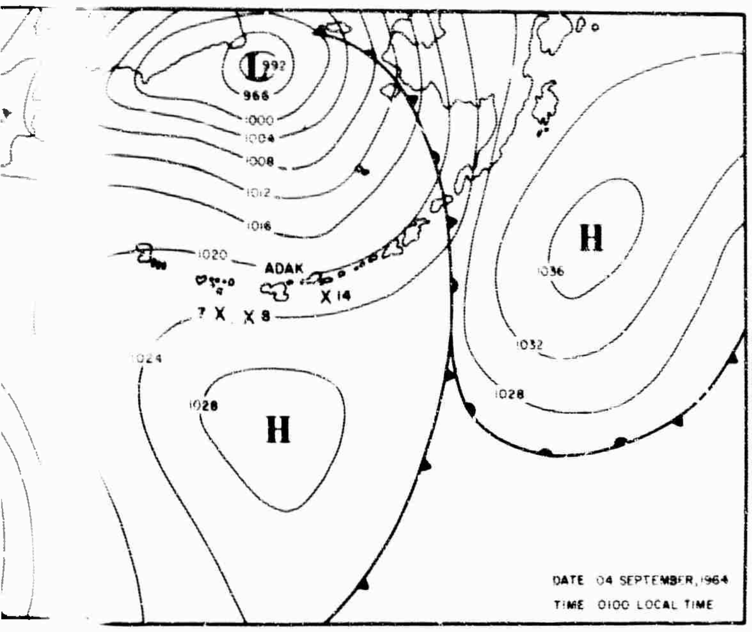
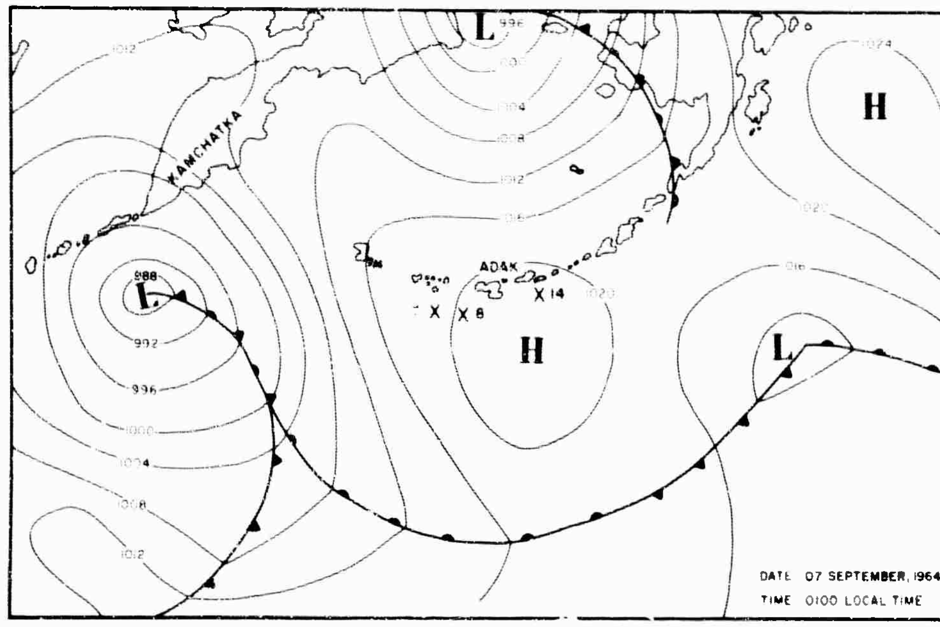
TIME 0100 LOCAL TIME
DATE 27 AUGUST, 1964
TIME 0100 LOCAL TIME
DATE 28 AUGUST, 1964
TIME 0100 LOCAL TIME

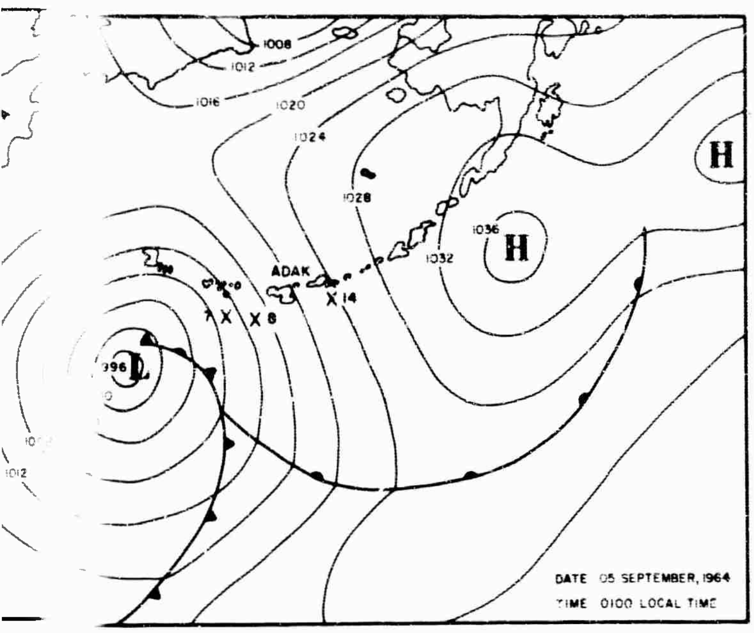
A


KAMCHATKA
ADAK
DATE 29 AUGUST, 1964
TIME 0100 LOCAL TIME
DATE 01 SEPTEMBER, 1964
TIME 0100 LOCAL TIME
DATE 30 AUGUST, 1964
TIME 0100 LOCAL TIME
DATE 02 SEPTEMBER, 1964
TIME 0100 LOCAL TIME
DATE 31 AUGUST, 1964
TIME 0100 LOCAL TIME
DATE 03 SEPTEMBER, 1964
TIME 0100 LOCAL TIME

B







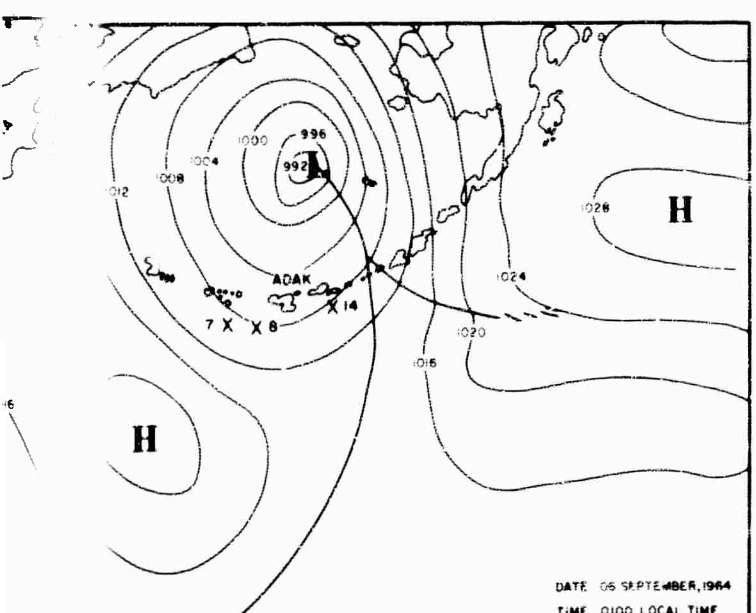


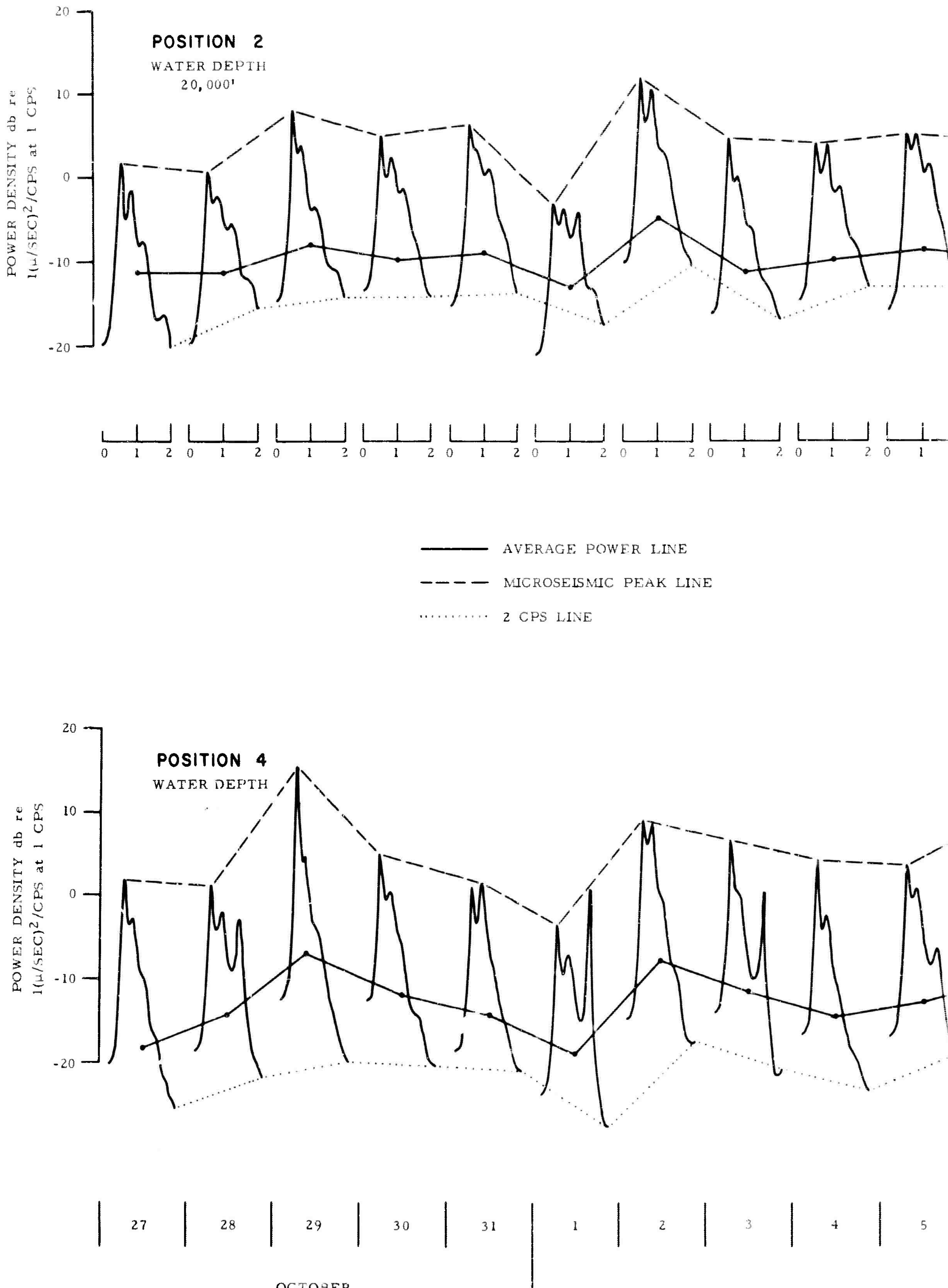
FIG 3

SURFACE ANALYSIS CHARTS
FROM U S NAVAL WEATHER
SERVICE , ADAK

Contours : Millibars

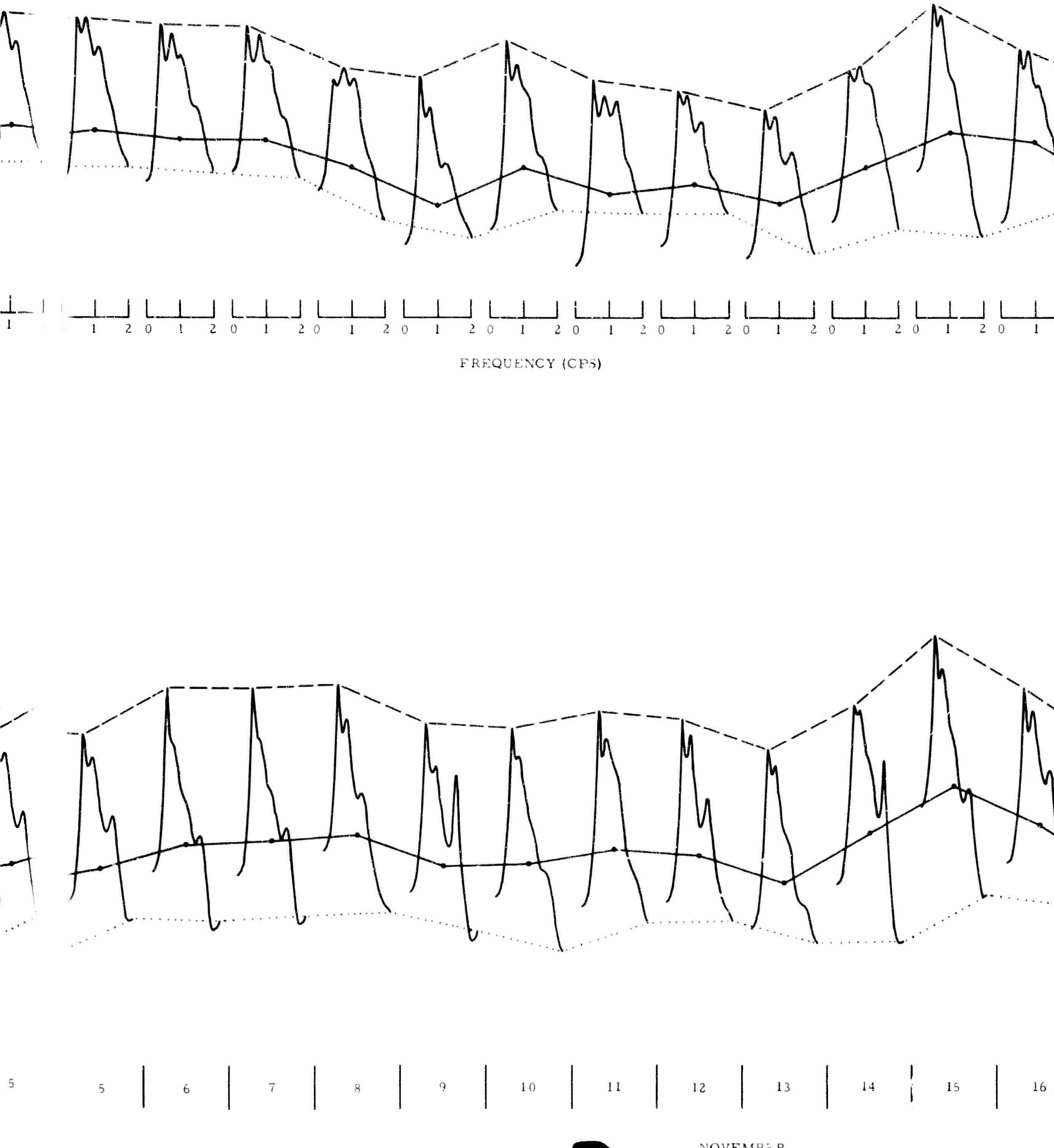
SCALE: 1" ≈ 1000 miles

C



TIME OF ALL NOISE SAMPLES
IS APPROXIMATELY 08:00 LOCAL TIME

A



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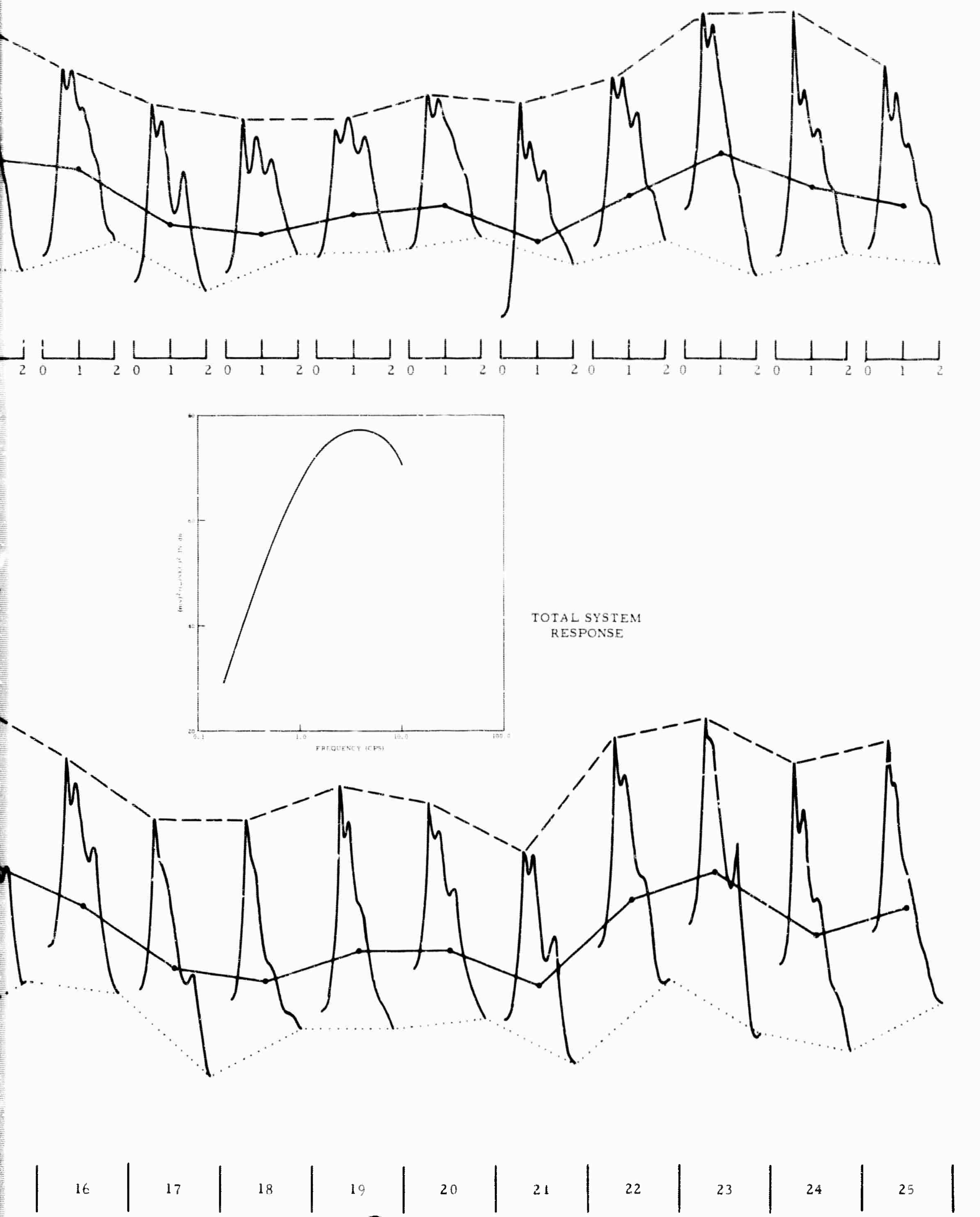

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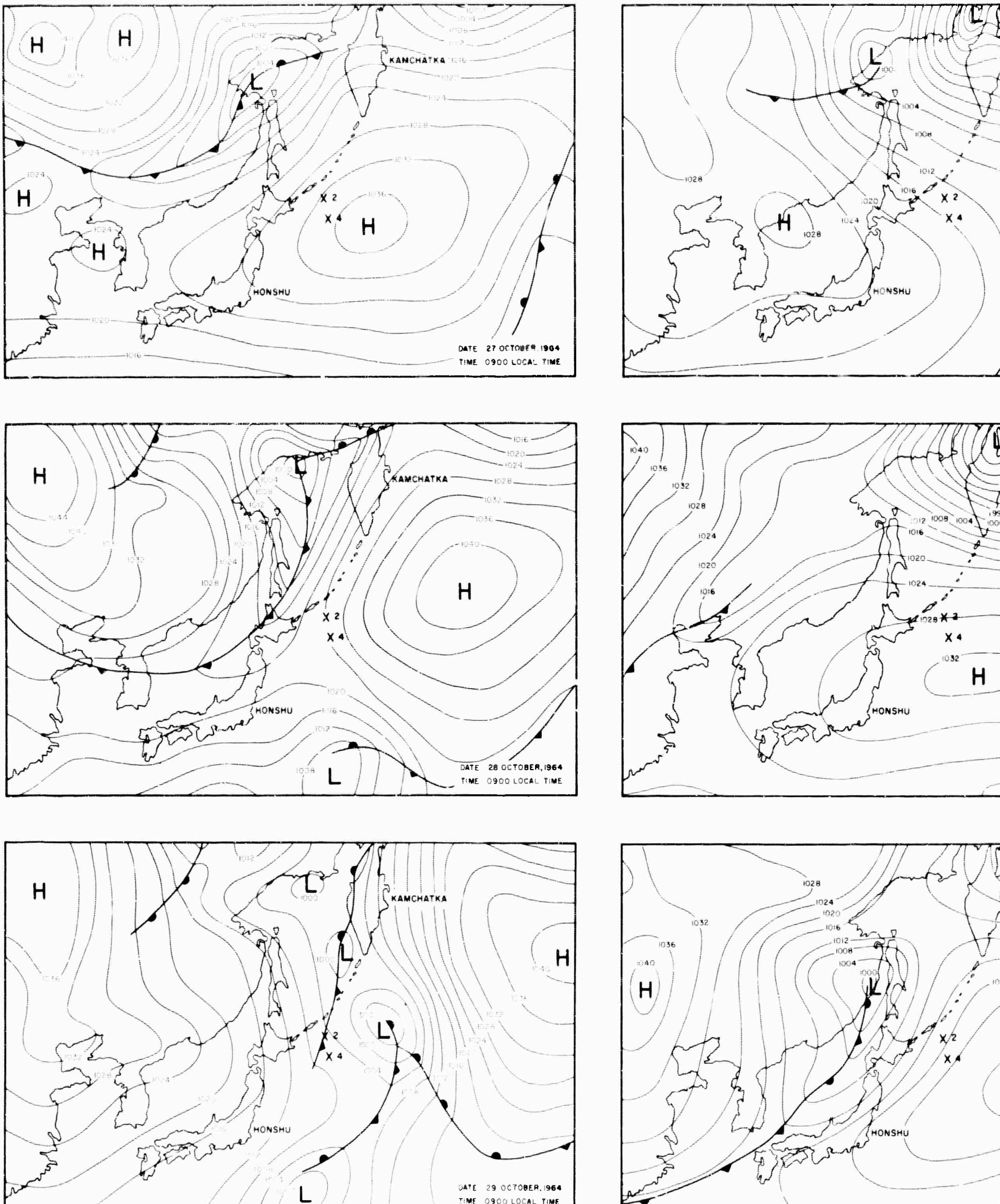
Figure 6. Spectral Variations with Time in the 0 to 2.0 CPS Band, Kuriles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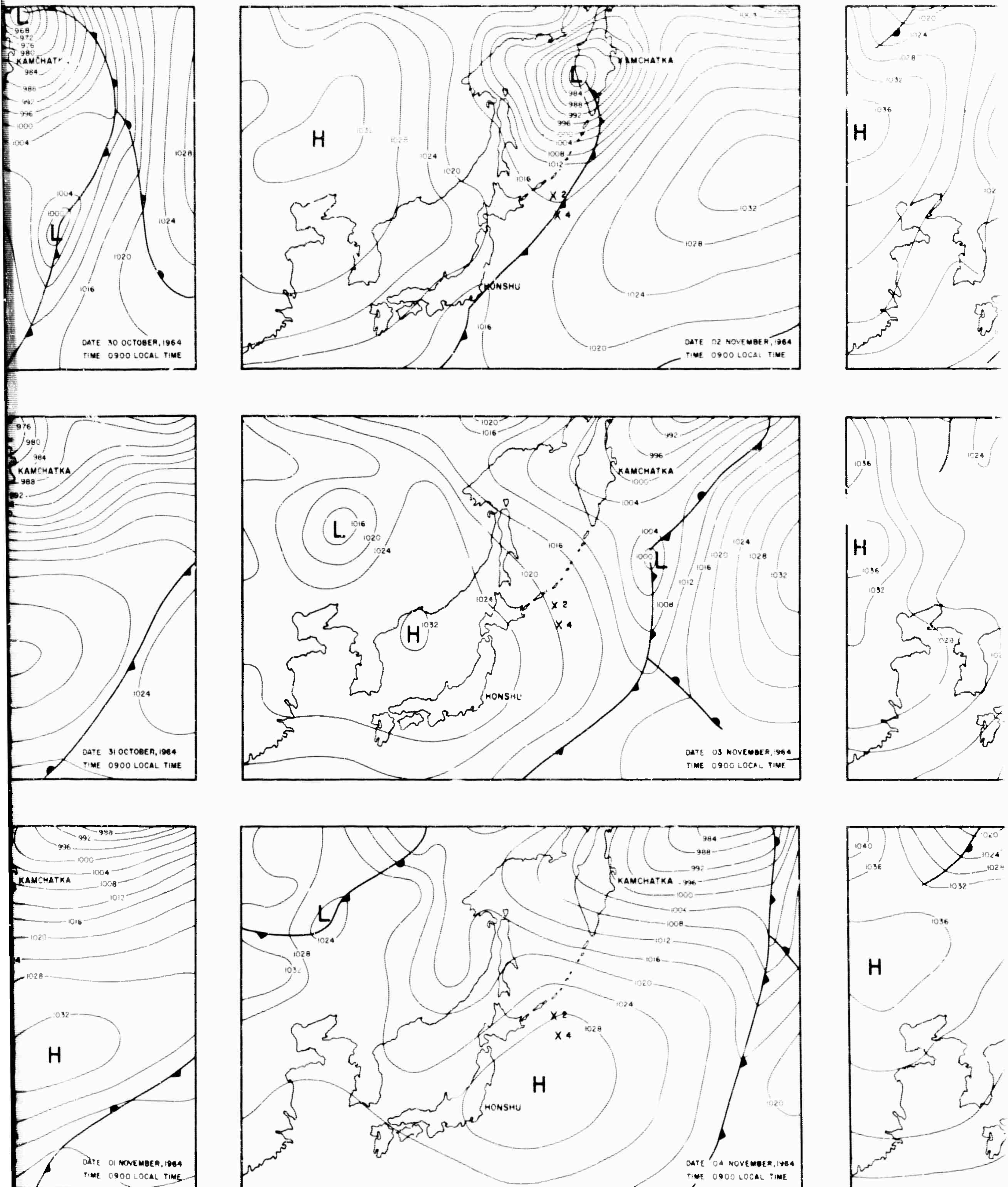
HONSHU
DATE 27 OCTOBER, 1964
TIME 0900 LOCAL TIME
HONSHU
KAMCHATKA
HONSHU
DATE 28 OCTOBER, 1964
TIME 0900 LOCAL TIME
HONSHU
KAMCHATKA
HONSHU
DATE 29 OCTOBER, 1964
TIME 0900 LOCAL TIME
HONSHU

A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TIME 0900 LOCAL TIME
KAMCHATKA
HONSHU
DATE 02 NOVEMBER, 1964
TIME 0900 LOCAL TIME
KAMCHATKA
DATE 31 OCTOBER, 1964
TIME 0900 LOCAL TIME
KAMCHATKA
HONSHU
DATE 03 NOVEMBER, 1964
TIME 0900 LOCAL TIME
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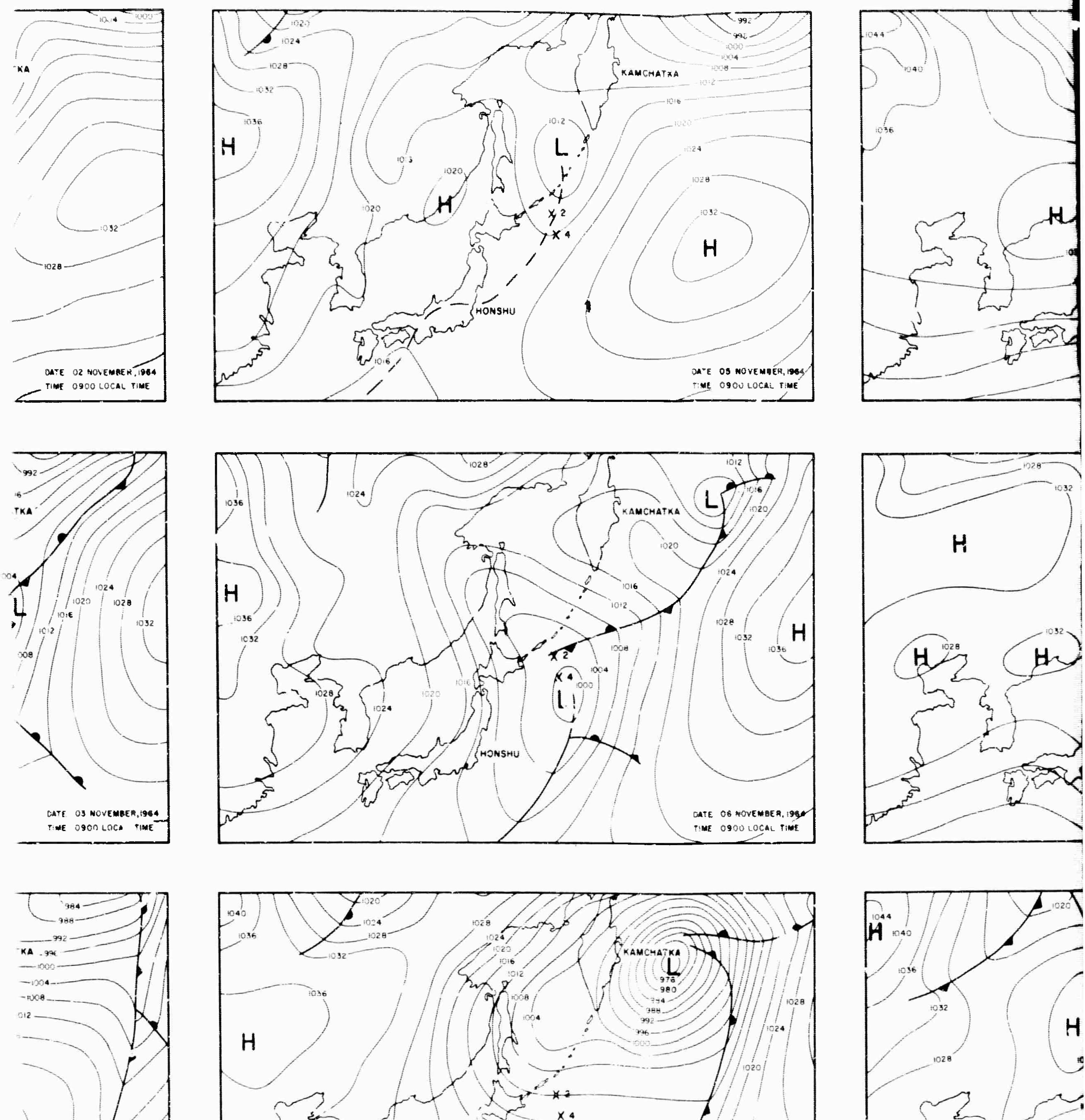
KAMCHATKA
HONSHU
DATE 04 NOVEMBER, 1964
TIME 0900 LOCAL TIME

B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TIME 0900 LOCAL TIME
KAMCHATKA
HONSHU
DATE 05 NOVEMBER, 1964
TIME 0900 LOCAL TIME
DATE 03 NOVEMBER, 1964
TIME 0900 LOCAL TIME
KAMCHATKA
HONSHU
DATE 06 NOVEMBER, 1964
TIME 0900 LOCAL TIME
DATE 04 NOVEMBER, 1964
TIME 0900 LOCAL TIME
KAMCHATKA
HONSHU
DATE 07 NOVEMBER, 1964
TIME 0900 LOCAL TIME

C

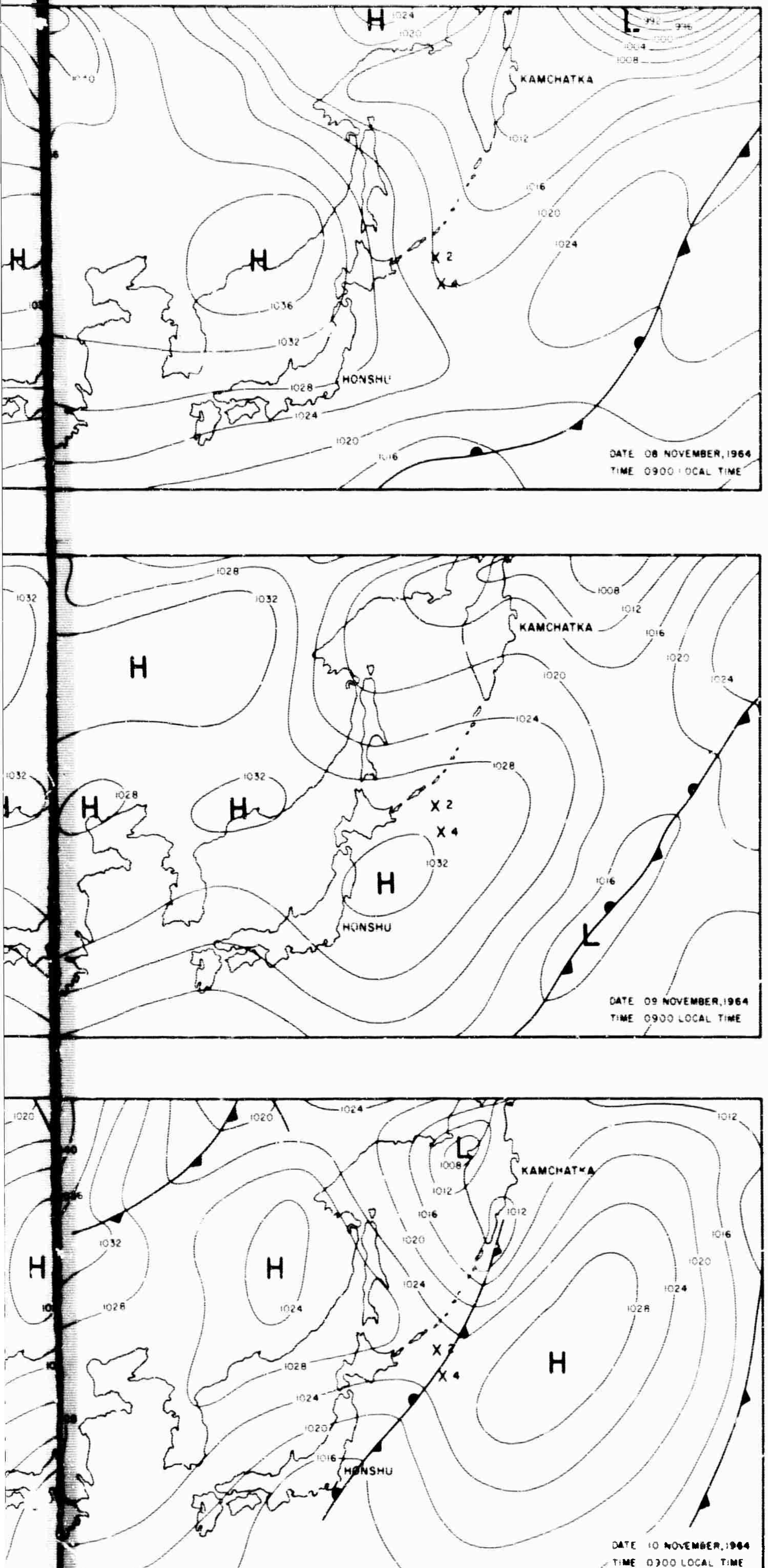


FIG 7

SURFACE ANALYSIS CHARTS

OCT. 27–NOV. 10, 1964

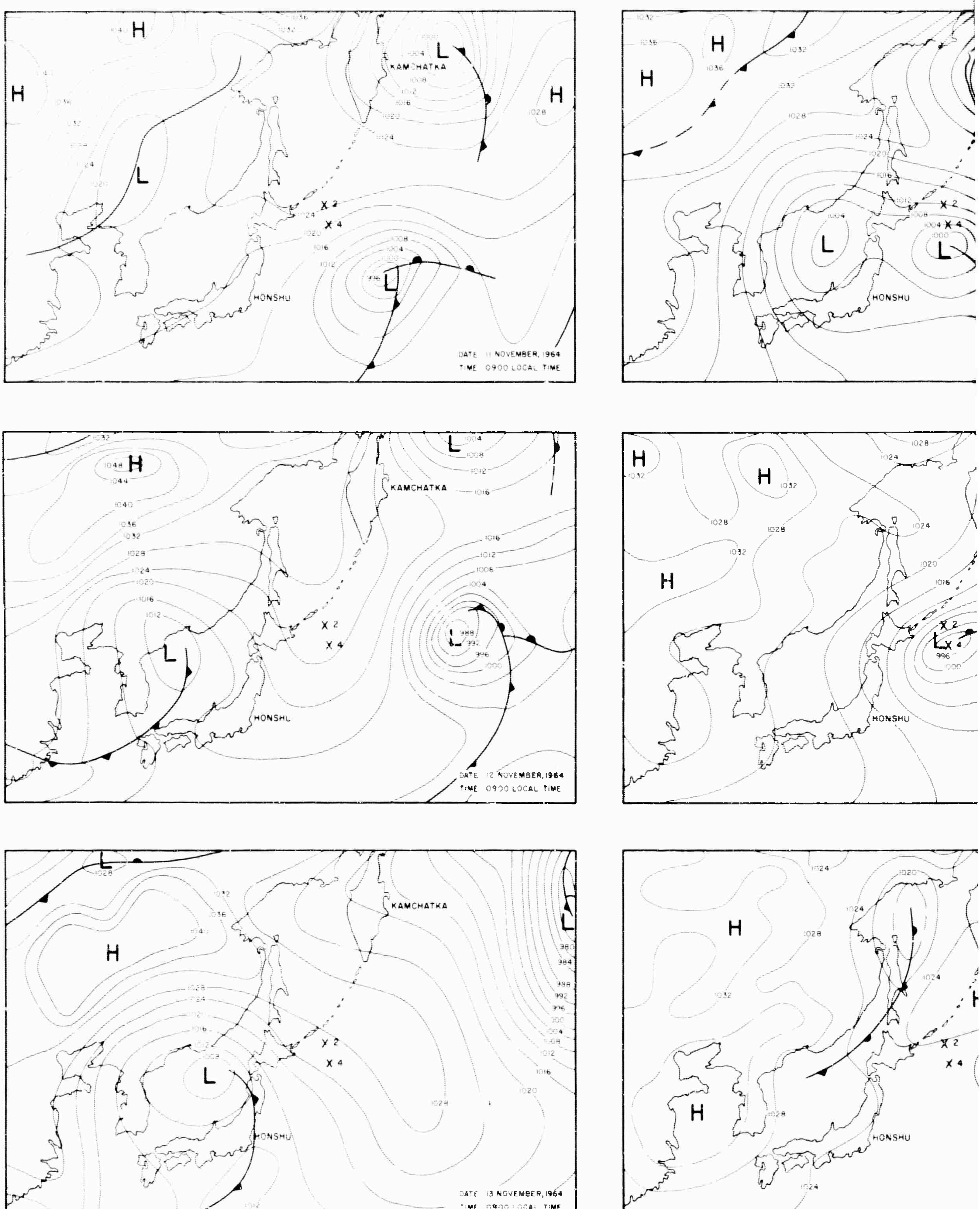
FROM U.S. WEATHER

BUREAU CHARTS

CONTOURS: MILLIBARS

SCALE: 1" ≈ 1250 miles

D


KAMCHATKA
HONSHU
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TIME 0900 LOCAL TIME
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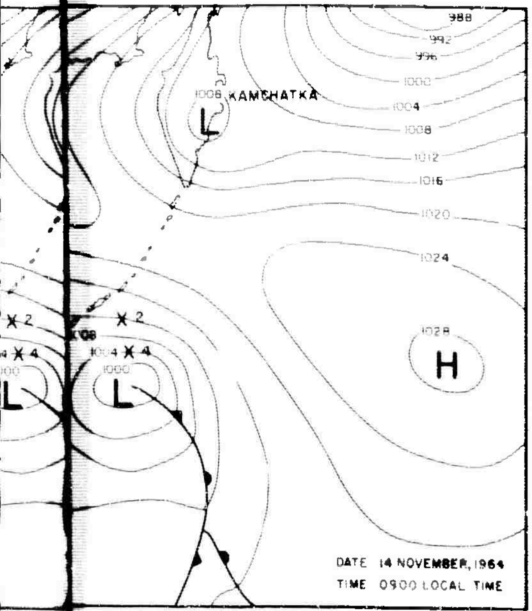
DATE 13 NOVEMBER, 1964
TIME 0900 LOCAL TIME

A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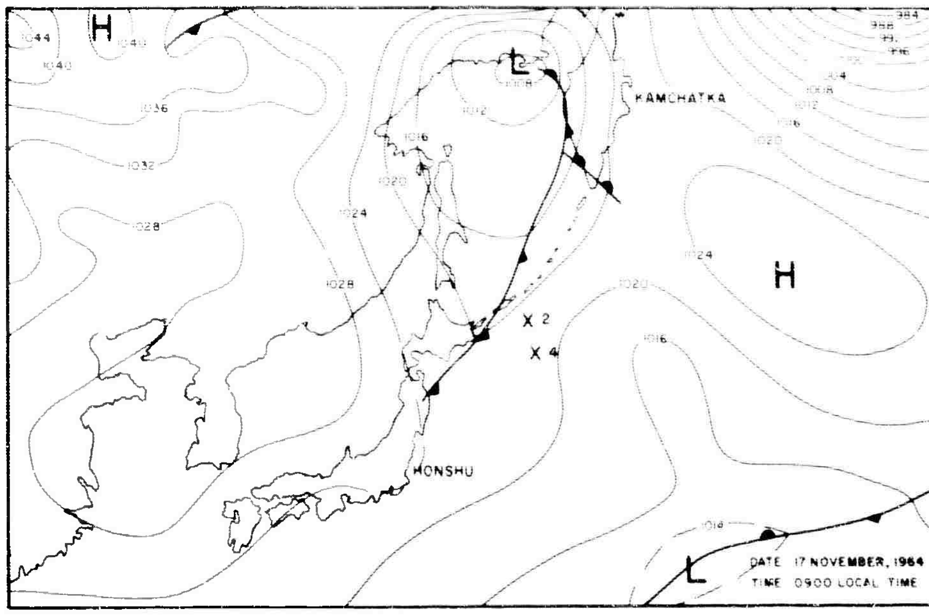
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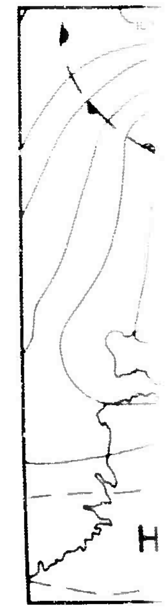

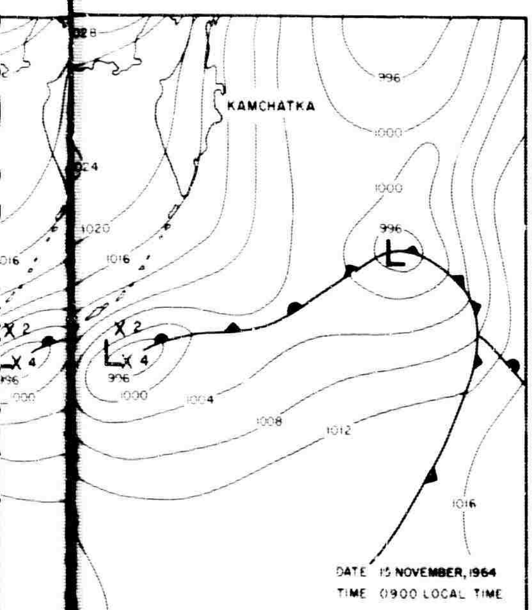
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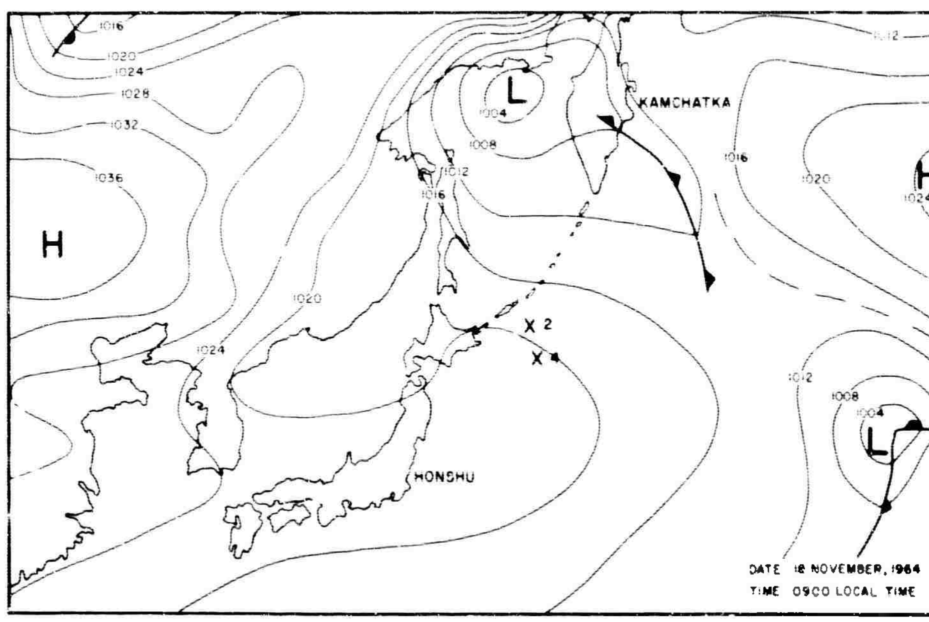
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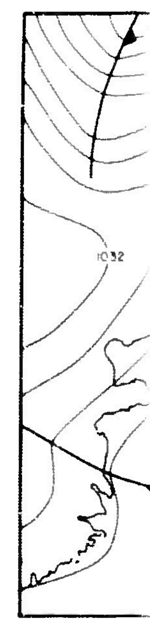

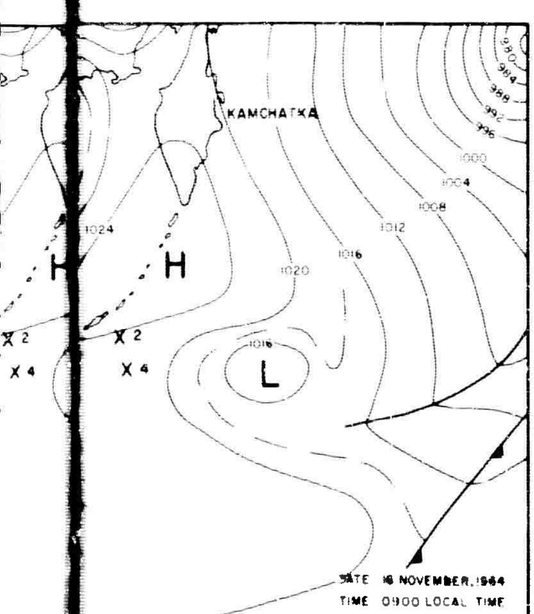
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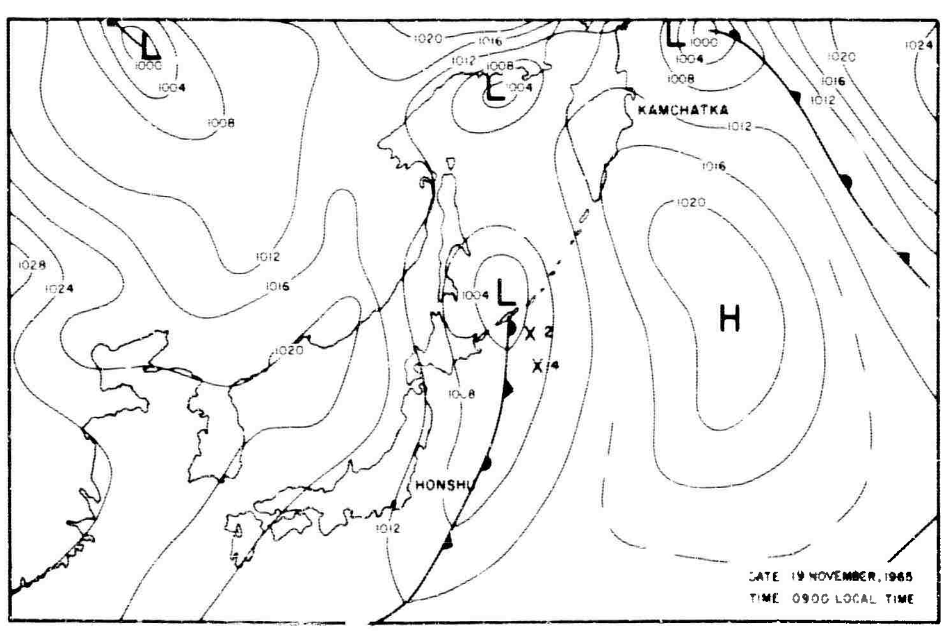
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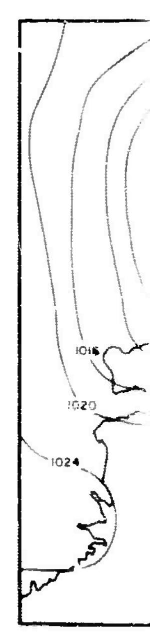

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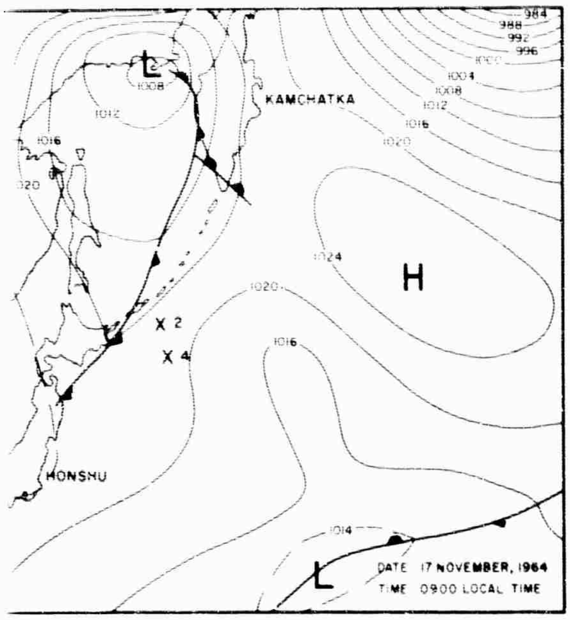
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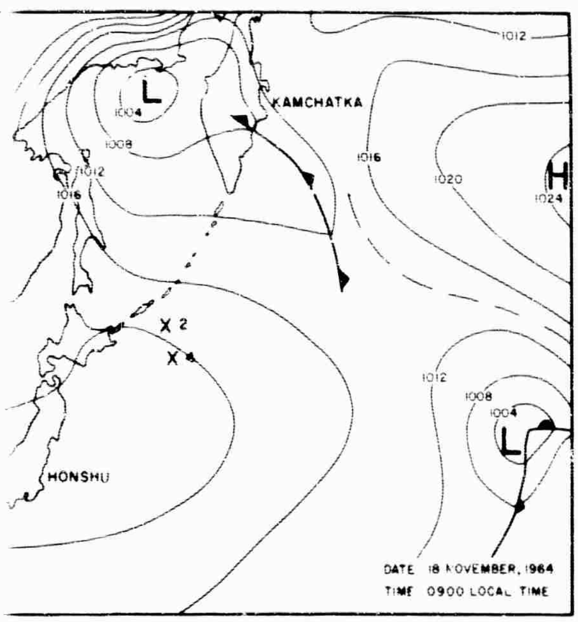
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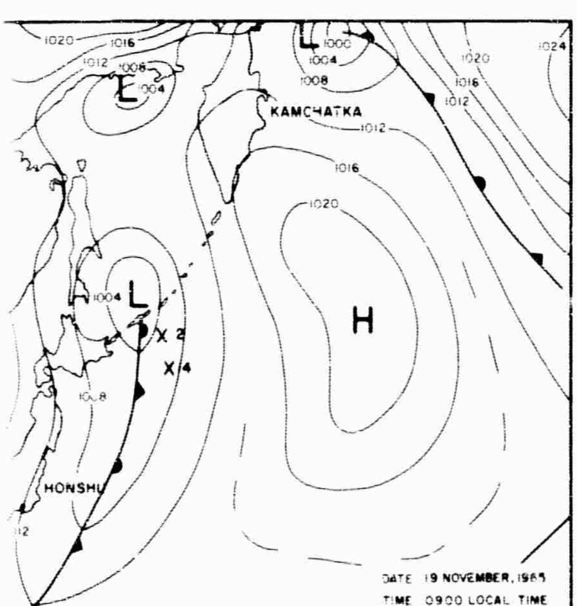
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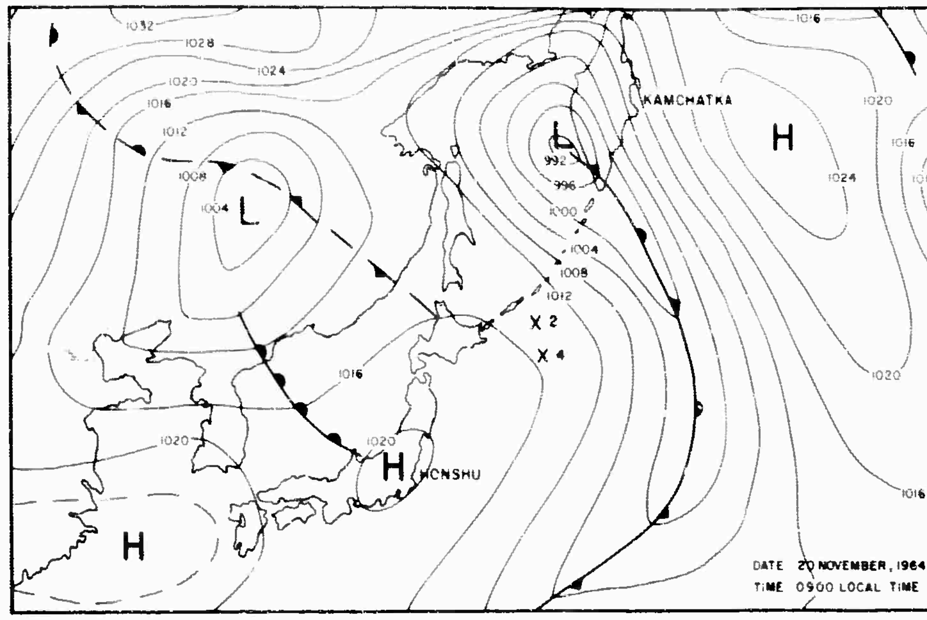
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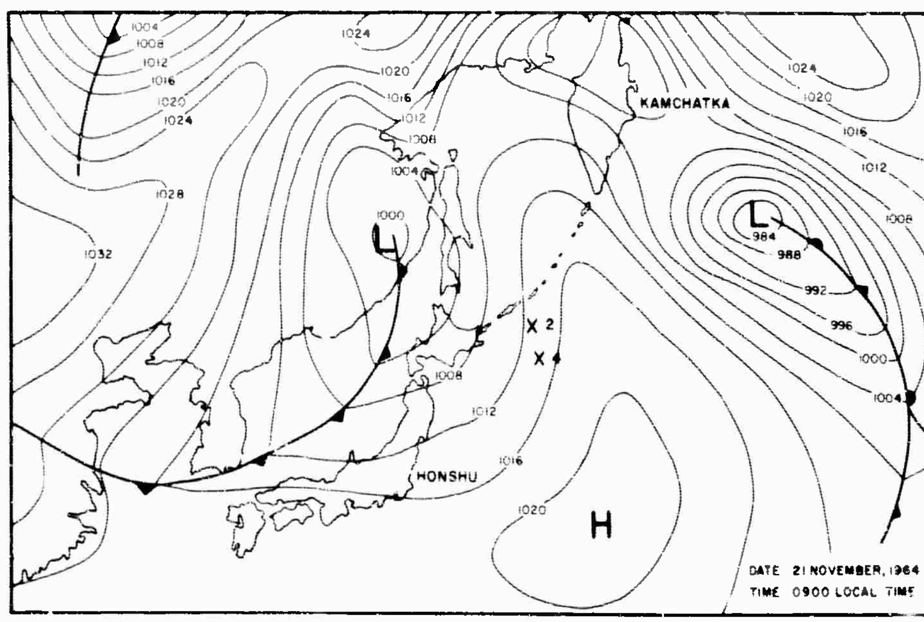
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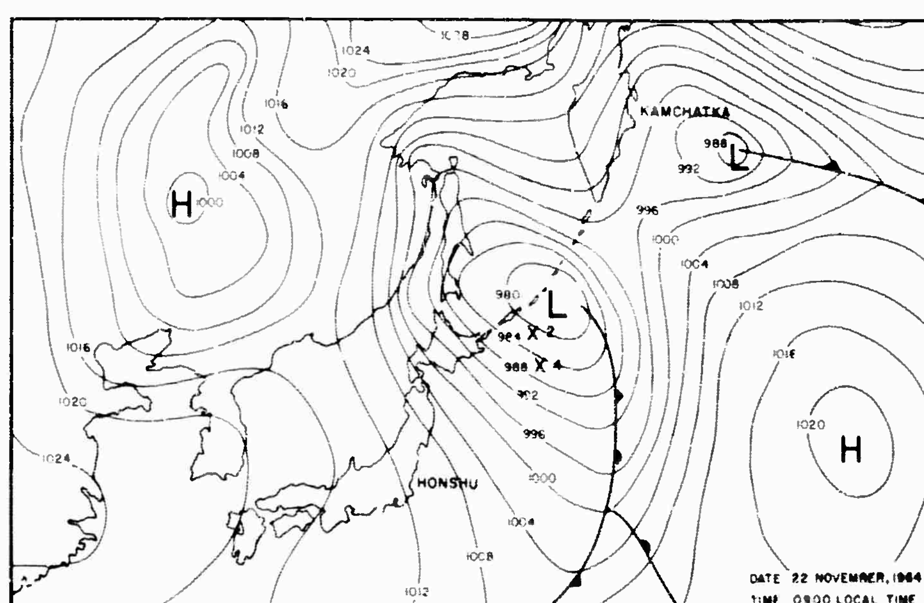
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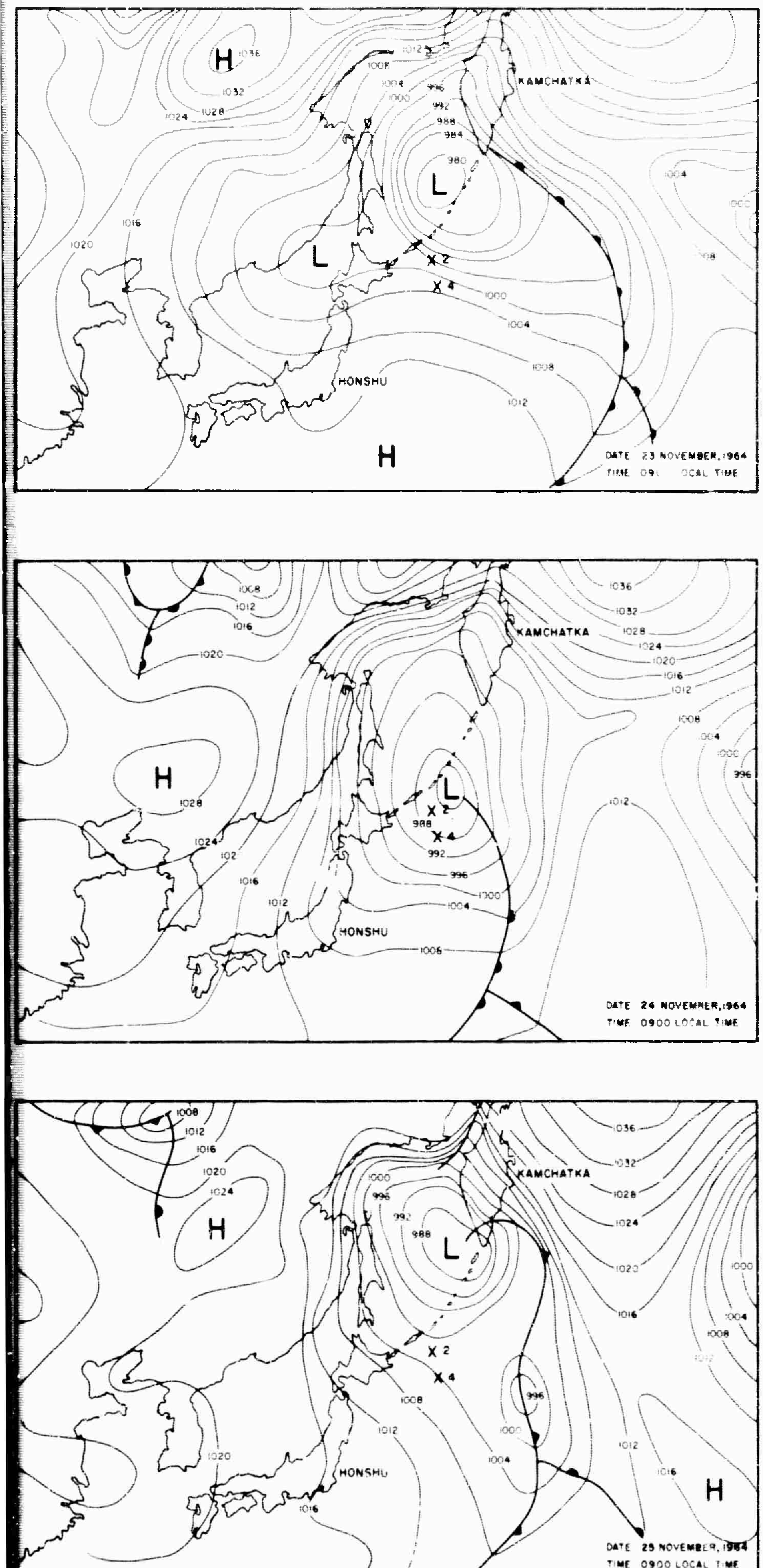

FIG 8

SURFACE ANALYSIS CHARTS

NOVEMBER 11–25, 1964

FROM U.S. WEATHER

BUREAU CHARTS

CONTOURS : MILLIBARS

SCALE: 1" ≈ 1250 miles

D

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Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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13. ABSTRACT

The 30-day ocean-bottom seismograph senses ground motion through 1 vertical and 2 horizontal velocity seismometers and pressure variations through a transducer capable of response to 1.0 cps.

Data are recorded continuously on magnetic tape and the unit has a depth capability of 25,000 ft.

During the summer and fall of 1964, several drops were made in the area south of the Aleutian chain and northeast of the Island of Hokkaido, Japan.

Power density spectra of ambient noise samples over a long time interval were selected from the two areas. Plots of these data vs time are presented and compared with simultaneous meteorological maps covering the respective areas.

These results show a direct relationship between ambient noise levels and local meteorological changes. In fact, low-pressure disturbances were observed to cause up to 20 db increase in ambient noise level in the 0-2.0 cps range.

Ambient noise levels that previously were observed and reported appear consistent with current findings.

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UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Ocean Bottom Seismograph						
Data Collection						
Data Editing						
Data Analysis Aleutian Area						
Data Analysis Kurile Area						

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